13 Appendix A: Management Unit Status Profiles

13.1 Nooksack River Management Unit Status Profile

Component Stocks

North Fork Nooksack early chinook
South Fork Nooksack early chinook

Geographic description

The Nooksack River natural chinook management unit is comprised of two early-returning, native chinook stocks that are genetically distinct, geographically separated, and that exhibit slightly different migration and spawning timing. They have been combined into a management unit because their passage through the fishing areas in the Nooksack River, below the confluence with the South Fork, and Bellingham and Samish Bays are similar and distinct from the migration timing of the Nooksack hatchery chinook stocks of Green River origin in the same areas.

The North Fork drains from high altitude, glacier-fed streams. Early-timed chinook spawn in the North Fork from the confluence of the Middle Fork (RM 40) up to the Excelsior Powerhouse at RM 65, and in several tributaries including Glacier, Cornell, Canyon, Maple, Kendall, and Racehorse creeks. A hatchery based egg bank and restoration program has operated at the Kendall Creek facility since 1981. Up to 2.3 million fingerlings, 142,458 unfed fry and 348,000 yearlings have been released annually into the North Fork, or various acclimation sites. The yearling release program was discontinued after it was shown to produce returns at rates no better than those produced by fed fry releases.

The South Fork drains a lower-elevation watershed in the foothills, with a markedly different hydrograph and temperature regime than the North Fork. Early chinook spawn in the upper South Fork up to RM 30.4, and in Hutchinson and Skookum creeks. An hatchery-based egg bank and restoration program operated at the Skookum Creek facility in brood years 1980 – 1993, but was discontinued when the natural returns to the hatchery ladder did not materialize in significant numbers, and the capture of wild broodstock was not deemed appropriate at such low abundance.

Allozyme analysis of samples collected from both stocks indicates significantly different frequencies of common allozymes, but there are fewer differences in allele frequencies between the two native stocks than between the native stocks and fall hatchery stock, suggesting that they have distinct evolutionary history.

Life History Traits

Nooksack early chinook are characterized by early entry into freshwater, a slow upstream migration, and lengthy residence in the river prior to spawning. The North Fork stock enters the lower Nooksack River from March through July, slowly moves up the river and spawns in the upper reaches from August through late September. The peak of spawning for the South Fork stock occurs two to three weeks later than that of the North

Fork stock. Spawning is concentrated in the North Fork, from RM 44 to RM 64, but also occurs in tributary streams and the Middle Fork. In the South Fork spawning is concentrated between RM 23 and RM 30. Efforts are currently underway to better describe the spawning distribution throughout the Nooksack Basin. There have been few recoveries of coded-wire tagged North Fork-origin chinook on spawning grounds in the South Fork during periods of low North Fork stock escapement, suggesting that stray rate of returning adults is low

Naturally produced smolts from the North Fork are predominantly (91 percent) age-0 (WDFW 1995 cited in Myers et al 1998). In the South Fork, yearling smolts making up a larger and highly variable (as much as 69 percent) proportion of the annual production (WDFW 1995 cited in Myers et al 1998).

The recent average (1986 – 1994) age composition of adults returning to the North Fork indicates that age-3, age-4, and age-5 fish comprise 4 percent, 75 percent, and 20%, respectively of annual returns. The age composition of returns to the South Fork, for the same period, averaged 10 percent, 61 percent, and 28 percent, respectively (WDF et al 1993 and WDFW 1995 cited in Myers et al 1998). Age-5 proportions of these magnitudes are also observed among other Puget Sound spring chinook stocks, e.g. the Suiattle River and White River.

Status

The current status of the Nooksack early chinook stocks is critical, due to chronically low returns and poor freshwater survival. The SASSI review (WDF et al 1993) reached the same conclusion. While spawning escapement to the North Fork has increased slightly in recent years, (i.e. the geometric mean for all returns in 1997 – 1999 was 592, compared with 261 for 1992 – 1996), it remains below 200 in the South Fork. Survey effort has increased to better estimate the abundance and distribution of spawners throughout the Nooksack Basin, but the glacial nature of the North Fork hampers efforts to enumerate live fish or redds. Progeny of the hatchery program is essential to the recovery of the stock, and is therefore included with the listed stocks. Kendall Creek hatchery production contributes significantly to the abundance and return of the North Fork stock.

Table 1. Spawning escapement of Nooksack early chinook, 1990-2000.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
North Fork	10	110	490	440	40	228	538	621	366	911	1242
South Fork	142	365	103	235	118	290	203	180	157	213	283

The status of the North Fork stock appears less critical than that of the South Fork stock, given recent spawning escapement levels. North Fork escapement in the last three years has been more than three times the average for the preceding five-year period (1992-96), while South Fork escapement has been stable at about 200 for the last five years.. Degraded fresh water habitat has contributed to low spawner success and egg-to-fry survival.

Increasing escapement to the North Fork (Table 2) suggests that terminal harvest rates have declined, but the recruits per natural-origin spawner have consistently remained below one recruit per pair of spawners. Preliminary estimates of the proportion of natural origin spawners in the North Fork, as determined from otolith studies, indicate that the return rate of natural origin spawners for brood years 1992 through 1995 ranged from 0.14 to 0.62 per spawner (Table 3), well below the replacement rate. This would suggest that something other than the limited incidental terminal area harvest is responsible for the decline of the natural origin spawners.

Table 2: Origin of Spawners in the North Fork Nooksack River (Lummi DNR unpublished data).

Return Year	Natural Origin	Cultured Origin	Total
1995	175	53	228
1996	210	328	538
1997	121	500	621
1998	39	327	366
1999	91	820	911
2000	160	1082	1242

Table 3. Natural origin return per spawner rates for early chinook in the North Fork of the Nooksack River (Lummi DNR unpublished data).

Brood year	Natural spawners	Total age 3 - 6 Returns	Return per Spawner
1992	493	181	0.37
1993	445	95	0.21
1994	45	28	0.62
1995	230	32	0.14
1996	535	171	0.32

Comparison of brood year escapement in the South Fork to escapement four years later indicates that the average replacement rate has been 1.17 (Table 4).

Table 4. Replacement rate of early chinook in the South Fork Nooksack River.

Brood Year	Spawners	Spawners (BY+4)	Replacement Rate
1991	365	290	0.79
1992	103	203	1.97
1993	235	180	0.77
1994	118	157	1.33
1995	290	213	0.73
1996	203	283	1.39
		average	1.17

Harvest distribution

Recoveries of coded-wire tagged North Fork early chinook indicate that a majority of the historic harvest mortality occurs outside of Washington waters, primarily in Georgia Strait and other net and recreational fisheries in British Columbia (Tables 5 and 6). The principal of abundance-based management of chinook, which were agreed to in the re-negotiated Pacific Salmon Treaty Chinook Annex in 1999, may constrain harvest of Nooksack early chinook in Georgia Strait, where they comprise less than one percent of the total catch. Conservation measures aimed at reducing spring chinook harvest in the Strait of Juan de Fuca and northern Puget Sound have been in place since the late 1980's. There have been no directed fisheries in Bellingham Bay and the Nooksack River since the late 70's. Incidental harvest in fisheries directed at fall chinook in Bellingham Bay and the lower Nooksack River was reduced in the late 80's by severely reducing July fisheries. Since 1997, there has been a very limited subsistence fishery in the lower river in early July, no tribal commercial fisheries until August and no Non-tribal commercial fisheries until mid-August. Since 1997 the release of summer fall chinook from the Kendall hatchery was moved down to the tidal portion of the river and then to the Maritime heritage center on the eastern shore of Bellingham bay, and then eliminated entirely. This has shifted the emphasis of the terminal area fishery away from the Nooksack River to the Samish Bay and Lummi Bay
areas and reduced the proportion of the tribal harvest taken in the Nooksack River

Table 5. Adult-equivalent exploitation rates for Nooksack early chinook in regional fishery aggregates (unpublished CTC data cited in NMFS 2000).

Brood years	Total	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	.61	.01	.35	.01	.25
1991-94 avg	.43	0	.28	0	.14

Table 6. The distribution of harvest mortality of Nooksack early chinook in coastal fisheries in Alaska, British Columbia, and Washington. (from CTC 1999).

Catch year	Alaska	Nrthcent B.C.	WCVI	Geog Strait	B.C. Net	B.C. sport	Wa troll	Wa net	Wa sport
1986-90 avg	0%	2.0%	4.3%	47.1%	5.5%	0.7%	0.7%	18.9%	20.7%
1991-96 avg	0.9%	2.4%	9.7%	56.1%	3.3%	5.1%	1.4%	5.9%	15.2%

Coded-wire tag recoveries indicate that, in Washington waters, Nooksack early chinook have been caught in the Strait of Juan de Fuca troll fishery, recreational fisheries in southern and northern Puget Sound, and net fisheries (primarily in Areas 7 and 7A, Bellingham Bay, and the Nooksack River) in northern Puget Sound (Table 7). This tag information may not represent the constrained, current fishing regimes in all areas, particularly in Puget Sound since 1997, or the potentially different migration pathways of yearling and fingerling hatchery releases. The Kendall Creek facility currently releases only subyearling early chinook.

Table 7. Distribution of harvest-related mortality (percent of total mortality) of Nooksack early chinook in Washington fisheries, 1991 – 1993 (J. Guttman unpublished data, NWIFC).

	Catch Years		
Washington Fishery	1991	1992	1993
Ocean Troll	0%	0%	0%
Ocean Sport	0%	0%	0%
Juan de Fuca Troll	2%	1%	0%
Areas 5-7 Sport	3%	7%	5%
Areas 8-13 Sport	3%	2%	5%
Puget Sound Net	4%	0%	4%
Terminal Net	4%	1%	1%

Exploitation rate trends:

The Chinook Technical Committee (CTC) of the Pacific Salmon Commission calculated fishery exploitation rates for Nooksack early chinook for brood years 1981 – 1994 (data for brood years 1983, 1985, and 1991 were not available), based on CWT recoveries. Fishery-related mortality of sub-adult chinook was adjusted for adult equivalency, according to methods standardized by the CTC. For the eight most recent brood years, for which tag recovery of all year classes is complete, the adult equivalent fishery exploitation rate has ranged from 86 per cent to 39 percent (Table 8). Exploitation rates have declined over this period, which may, in part, account for the modest increase in North Fork escapement, and apparent stability of South Fork escapement. Computation of these rates is based on recoveries of marked chinook produced at Kendall Creek. There are insufficient tag data from the Skookum Creek production to enable a specific computation for the South Fork stock.

Table 8. Total fishery-related AEQ exploitation rate of Nooksack early chinook for brood years 1986 – 1994 (Unpublished CTC analyses cited in NMFS 2000).

1986	1987	1988	1989	1990	1991	1992	1993	1994
.86	.53	.58	.55	.55	-	.39	.45	.44

Management Objectives

The management objectives for Nooksack early chinook constrain harvest under co-manager jurisdiction so that it will not impede recovery, while allowing for the exercise of treaty-reserved fishing rights and providing non-treaty fishing opportunity.

Degraded spawning and rearing habitat present the most significant constraint on productivity, so an ambitious and long-term effort to restore habitat, working in concert with appropriate hatchery production and harvest management regimes, is essential to recovery. The potential for hatchery production, net and recreational fisheries to alter the age and size composition of adult returns is recognized, so harvest managers will collect information to determine if current regimes are having such an effect, and will develop measures to reduce selectivity if it is identified.

For the next two years it is not expected that the abundance of natural origin spawners returning to either of the Nooksack early chinook stocks will exceed the critical abundance thresholds. The co-managers and the NMFS will work together toward the development of an acceptable recovery exploitation rate to be implemented when the returning abundance of natural origin spawners exceeds the critical abundance threshold for both stocks.

When the projected escapement to the spawning grounds, in preseason modeling, is below the critical abundance threshold of 1,000 natural spawners for either of the Nooksack early chinook stocks, fisheries that impact the escapement of these stocks will be shaped so the exploitation rate in southern US fisheries, that is defined by modeling the fisheries regime listed in Appendix C with the current season's forecast abundance, is not exceeded.

With approximately 70 percent of the historic total harvest mortality occurring in Canadian fisheries, the scope for reducing fisheries impacts in Washington waters is limited. Net, troll, and recreational fisheries in Puget Sound have been shaped to minimize incidental chinook mortality to extent possible while maintaining fishing opportunity on other species such as sockeye and summer/fall chinook. The net fishery directed at Fraser River sockeye, in catch areas 7 and 7A in late July and August, has caught very few Nooksack early chinook. Chinook fisheries in Bellingham Bay and the Nooksack River are delayed until early chinook have cleared the fishing areas, entered freshwater, or in the case of river fisheries, until migration to upstream spawning and holding areas has occurred. There will be a limited harvest of an Nooksack early chinook in the river for the purpose of a tribal first salmon ceremony, amounting to a single fish and such additional chinook that are entangled before the net is removed from the water (total not to exceed five chinook). Limited tribal fisheries for ceremonial and subsistence purposes will occur in early July to meet minimal tribal requirements. Fisheries in Bellingham Bay directed at fall chinook will not open prior to August 1. Subsequent fishing in the river occurs in progressively more upstream zones as early chinook stocks clear these areas. Thus the area extending two miles downstream of the confluence of the North and South Forks will not open prior to September 16.

Total exploitation rates projected by the FRAM model in the last two (management) years were 13 percent in 2000 and 20 percent in 1999. FRAM based Recovery exploitation rates were estimated by NMFS to be 17 percent and 21 percent for the North and South Fork stocks, respectively, based on a preliminary stock-recruit analysis (NMFS 2000). The FRAM chinook model has some difficulty in accurately representing the total exploitation rate on Nooksack early chinook stocks. It is recognized that tag data do not exist to support a direct analysis of the productivity of the South Fork stock, and given its status, there is ample reason to exert conservative caution in planning fishing regimes.

The co-managers are evaluating the productivity, abundance and diversity of the early chinook runs that could be expected from the Nooksack watershed under properly functioning habitat conditions that might have been expected to exist at Treaty time. The calculation of a normal exploitation rate has not be made but at the current escapement goal of 2000 natural origin spawners in each population, and an exploitation rate of 60%, a AEQ recruit abundance of 5,000 in each stock would be anticipated. It is not expected that these goals will change until that study is completed and validated.

Data gaps

Following are the highest priority needs for technical information necessary to understand stock productivity and refine harvest management objectives:

1) Improved estimates of total escapement to the North and South Forks by stock and region of origin.

2) Estimates of natural early chinook smolt production from the North and South Forks.

3) Development of stock/recruit functions, or component freshwater survival data to monitor the productivity of the two stocks.

13.2 Skagit River Management Unit Status Profiles

Component Stocks

Summer/fall chinook management unit
- Lower Sauk River (summer)
- Upper Skagit River mainstem and tributaries (summer)
- Lower Skagit River mainstem and tributaries (fall)

Spring chinook management unit
- Upper Sauk River
- Suiattle River
- Upper Cascade River

Geographic description

There are two wild chinook management units originating in the Skagit River system - spring and summer/fall chinook. The number of separate chinook populations within each of these units is unclear at this time. The co-managers (WDFW and WWIT 1994) identified three spring and three summer/fall populations. Analysis continues (Ruckelshaus et al. in prep) to resolve the population structure of each management unit.

Summer/fall management unit

The three populations tentatively identified within the summer/fall management unit are: Upper Skagit summers, Lower Sauk summers, and Lower Skagit falls. Upper Skagit summer chinook spawn in the mainstem and certain tributaries (excluding the upper Cascade River), from above the confluence of the Sauk River to Newhalem. Spawning also occurs in Diobsud, Bacon, Falls, Goodell, Illabot, and Clark creeks. Gorge Dam, a hydroelectric facility operated by Seattle City Light, prevents access above RM 96, but historical spawning in the high-gradient channel above this point is believed to have been very limited. The lower Sauk summer stock spawns primarily from the mouth of the Sauk to RM 21 - separate from the upper Sauk spring spawning areas above RM 32. The lower mainstem fall stock spawns downsteam of the mouth of the Sauk River, and in the larger tributaries, including Hansen, Alder, Grandy, Jackman, Jones, Nookachamps, Sorenson, Day, and Finney creeks.

Skagit summer/fall stocks are not currently supplemented to a significant extent by hatchery production. A PSC indicator stock program collects summer broodstock (about 40 spawning pairs per year) from the upper river. Eggs and juveniles are reared at the Marblemount Hatchery. The objective of the program is to release 200,000 coded-wire tagged fingerlings for monitoring catch distribution and harvest exploitation rate. Summer chinook fingerlings are acclimated in the Countyline Ponds before they are released. Development of a lower river fall indicator stock was initiated in 1999, with similar production objectives. Production programs for fisheries enhancement of Skagit summer/fall chinook, and plants of fall chinook fingerlings into the Skagit system from the Samish Hatchery have been discontinued.

Spring management unit

The Skagit spring management unit includes stocks originating in the upper Sauk, the Suiattle, and upper Cascade rivers. The upper Sauk stock spawns in the mainstem, primarily above the town of Darrington up to RM 40, the Whitechuck River, and tributary streams. The Suiattle stock spawns in several tributaries including Buck, Downey, Sulphur, Tenas, Lime, Circle, Straight, and Big creeks. Cascade springs spawn in the mainstem above RM 19, and are thus spatially separated from the lower Cascade summer chinook. Spring chinook reared from Suiattle River broodstock are released from the Skagit Hatchery. Annual releases averaged 112,000 yearlings for the period 1982 – 1991 (WDF et al 1993). Since then, about 250,000 subyearlings have also been released each year. All spring chinook releases are coded-wire tagged.

Life History Traits

The upper mainstem and lower Sauk River and summer stocks spawn from September through early October. Operational constraints imposed by the Federal Energy Regulatory Commission on the Skagit Hydroelectric Project's operation have, to some extent, mitigated the effects of flow fluctuations on spawning and rearing in the upper mainstem, and reduced the impacts of high flood flows by storing runoff from the upper basin. The lower river fall stock enters the river and spawns later than the summer stocks; spawning peaks in October. Age of spawning is primarily 4 years, with significant Age 3 and Age 5 fish. Most summer/fall chinook smolts emigrate from the river as subyearlings, though considerable variability has been observed in the timing of downstream migration and residence in the estuary, prior to entry into marine waters (Hayman et al 1996).

Spring chinook begin entering freshwater in April, and spawn from late July through early September. Adult spring chinook returning to the Suiattle River are predominantly age-4 and age-5 (WDF et al 1993 and WDFW 1995 cited in Myers et al 1998). Glacial turbidity from the Siuattle River and Whitechuck River limit egg survival in the lower Sauk River. Up to 82 percent of the smolts from the Siuattle River, and 45 percent of the smolts from the Sauk River, emigrate as yearlings (WDF et al 1993; WDFW 1995 cited in Myers et al 1998).

Status

Stocks that comprise the summer/fall management unit are depressed. Annual spawning escapement has fallen well below the nominal goal of 14,900 for most of the last ten years (Table 1), and has approached the critical threshold of 4,800 in 1997 and 1999. The geometric mean of the last four years' escapement was 8,833, an increase from the geometric mean of 1992-1996, 7,537 (Myers et al 1998). Recent assessment of freshwater productivity for summer/fall chinook suggests that the current MSY escapement is about 9,000 (NMFS 2000)..

Table 1. Spawning escapement of Skagit River chinook, 1990-1999.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sauk sum	1294	658	469	205	100	263	1103	295	460	295	576
U Skagit su	11793	3656	5548	4654	4565	5948	7989	4168	11761	3586	13092
L Skag fall	3705	1510	1331	942	884	666	1521	409	2388	1043	3262
S/F MU	16792	5824	7348	5801	5549	6877	10613	4872	14609	4924	16930
Cascade sp			205	168	173	226	208	308	323	83	273
Siuattle sp	685	354	201	292	167	440	435	428	473	208	388
Sauk Sp	557	747	580	323	130	190	408	305	290	180	360
Spg MU			986	783	470	856	1051	1041	1086	471	1021

Spawning escapements for the spring unit have also been consistently below the nominal goal of 3,000, but have, with the exception of 1994 and 1999, been above the critical threshold of 476 (Hayman 2000). The geometric mean of escapement in 1997 – 2000 was 859.

Harvest distribution

Coded-wire tagged Skagit summer/fall chinook were released in the 1970's, but, since that time, sufficient coded-wire tag recoveries to directly assess the harvest distribution of Skagit summer/fall chinook in recent years are not yet available. However, for PSC analyses, recoveries of marked fall chinook released from the Samish hatchery are believed to represent the pre-terminal harvest distribution of Skagit summer/falls. For the period 1991 – 1996, less than one percent of the total harvest-related mortality of Samish fingerlings occurred in Alaska, and 42 percent in British Columbia fisheries, primarily on the west coast of Vancouver Island and in Georgia Strait. Net fisheries in Puget Sound, and sport and troll fisheries in Washington incurred 30 percent, 20 percent, and 6 percent of total mortality, respectively (CTC 1999). The proportion of mortality in British Columbia fisheries has declined in recent years with the restriction of fisheries on the west coast of Vancouver Island, and other net fisheries.

The harvest distribution of Skagit spring chinook is described by recoveries of tagged yearling smolts released from the Skagit Hatchery. For the period of 1991 – 1996, 52 percent of fishery-related mortality occurred in British Columbia, primarily in Georgia Strait. Washington sport and net fisheries incurred 24 percent and 21 percent of total mortality, respectively.

Exploitation rate trends:

Fishery exploitation rates for Skagit spring chinook have been calculated for brood years 1981 – 1993, based on CWT recoveries (CTC unpublished data cited in NMFS 2000). Fishery-related mortality of sub-adult chinook was adjusted for adult equivalency, according to methods standardized by the Chinook Technical Committee. These data indicate that the total exploitation rate has been reduced from above 70 percent in brood years in the 1980's, to 50 percent for the most recent complete brood years. The annual (i.e., management year) exploitation rates have been less than 50 percent since 1993, according to post-season estimates from the FRAM model. The annual exploitation rate projected for Skagit springs by the FRAM model in 1999 and 2000 were 39 and 22 percent, respectively.

Table 2. Total fishery-related AEQ exploitation rates of Skagit spring chinook for brood years 1981 – 1994 (unpublished CTC data cited in NMFS 2000).

1981	1982	1983	1984	1985	1986	1987	1990	193	1994
.73	.84	.91	.78	.70	.73	.71	.57	.50	.50

Based on estimates from the CTC coastal fisheries model, the total exploitation rate of Skagit summer/fall chinook fell from above 60 percent in the late 1970's to below 40 percent in the period from 1986 – 1993.

Table 3. Total fishery-related AEQ exploitation rates of Skagit summer/fall chinook for brood years 1984 – 1993 (from PSSSRG 1997).

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
.47	.48	.39	.41	.38	.35	.34	.36	.34	.36

Annual (management year) exploitation rates for Skagit summer/falls, as estimated by the FRAM model with known catch and stock abundance ranged from 52 to 68 percent in the period 1990 – 1996 (Table 4), and declined to 38 percent in 1996. Total exploitation projected by the FRAM model pre-season in 1999 and 2000 were 35 and 29 percent, respectively.

Table 4. Total fishery-related AEQ exploitation rates of Skagit Summer/Fall chinook for management years 1983-96, from FRAM validation model runs**.**

1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
.79	.74	.67	.55	.66	.58	.74	.52	.63	.59	.68	.59	.63	.38

Management Objectives

The management objectives for Skagit summer/fall and spring chinook include recovery exploitation rates that insure, while maintaining fishing opportunity, that harvest will not impede recovery, and low abundance thresholds that guard against abundance falling below the point of instability (Hayman 2000). Recovery exploitation rate objectives were developed to meet the following criteria:

1) The percentage of escapements less than the critical escapement increases by less than 5 percentage points relative to the baseline (i.e., in the absence of fishing mortality).

   And either:

2) Escapements at the end of 25 years exceed the recovery level at least 80% of the time;

   or

3) The percentage of escapements less than the recovery level at the end of 25 years differs from the baseline by less than 10 percentage points.

The critical escapement is defined as that which would result in a 5 percent probability that the management unit would become extinct (i.e. fall below 100) at the end of ten years. Since a satisfactory method to calculate critical escapement has not been developed, escapement equal to 5 percent of the stock replacement level was chosen (Hayman 2000b). Replacement escapement is based on the current productivity of the management unit, and therefore incorporates parameters that define the Ricker stock / recruit functions for Skagit units, and recent freshwater and marine survival. For the summer / fall and spring units, the critical escapement levels are 1,165 and 220 (Hayman 2000a and 2000b).

The recovery escapement is that current level for which there is a 99 percent probability that the run will persist at viable levels. Put another way, if current exploitation rates and freshwater and marine survival conditions were maintained, the probability that the run would go extinct (i.e., fall below 100) at the end of 100 years would fall below one percent. Recovery escapements were computed by simulating the population dynamics for 100 years, given a recent average brood year exploitation rate and age composition of escapement, for a range of initial escapement levels. Simulations were replicated 2,000 times, until an initial escapement resulted in extinction in fewer than 1 percent of those replicate runs (Hayman 2000a and 2000b). Recovery escapement levels for summer/fall and spring units are 4,700 and 320, respectively.

With the critical and recovery escapement levels established, the population dynamics of the two Skagit units were simulated for 25-year periods into the future. The simulation model incorporated the average age composition and age-specific escapement of the units, and randomly or cyclically varying productivity and management error parameters. Each model run used an input exploitation rate, and was replicated 2000 times. The probabilities of exceeding the recovery escapement level, or falling below the critical escapement level, at the end of the simulation period were computed for each run from the 2000 outcomes. A range of exploitation rates, from 0 to 80 percent, were simulated to determine the maximum exploitation rate at which the conservation criteria were met (Hayman 2000a and 2000b). The Washington co-managers have set an exploitation rate guideline of 54 percent for the Skagit summer/fall management unit, and 54 percent for the spring management unit, as estimated from coded-wire tag recoveries. These management objectives were developed from productivity functions characteristic of brood years of Skagit chinook, and were translated into annual exploitation rates that are output from the FRAM model (Table 4). These exploitation rate objectives are set to be 82 percent of the mean rate from fishing years 1989-1993 for summer/falls, and 76 percent of the 1989 –1993 mean rate for springs. In the event that the FRAM calibration for the 1989 – 1993 fishing years changes, the numerical exploitation rate objectives used in FRAM (or other management model that is used for fishery planning) for Skagit summer/falls and springs will be changed to be 82 percent and 76 percent, respectively, of their re-calibrated 1989 – 1993 rates.

Low abundance thresholds ("crisis escapement levels") were also established for the summer/fall and spring management units. These thresholds are defined as the pre-season forecast escapement for which there is a 95 percent probability that the actual escapement will be above the point of instability, given management error and uncertainty about what level the point of instability is (Hayman 2000d). The derivation of these thresholds takes into account the difference between forecast and observed escapement in previous years, and variance of the spawner-recruit parameters used to calculate the point of instability, thereby reducing the probability of actual escapement falling below the actual point of stock instability. The derivation involved varying the preseason forecast until the area of overlap between the management error distribution curve and the uncertainty curve about the point of instability is less than 5% of the error distribution curve (Hayman 2000d).

In low-abundance years, when projected spawning escapement (from the FRAM model) fall to the lower thresholds, fisheries managers will implement further conservation measures in fisheries to reduce mortality, as described in Appendix C. For the summer/fall management unit, the low abundance threshold is 4,800; for the spring management unit, the low abundance threshold is 576. For the summer/fall unit, low abundance thresholds have been developed for each component population, so that forecast weakness in any one population may trigger the more conservative harvest regime. The crisis escapement thresholds for Upper Skagit summers, Lower Sauk summers, and Lower Skagit falls are 2,200, 400, and 900, respectively (Hayman 2000c). For spring chinook, data to calculate population-specific low abundance thresholds are not yet available.

The escapement of individual summer/fall populations may be projected from the aggregate escapement, which is output from the simulation model, in proportion to brood year escapement for each population, or in proportion to estimated age-3 and age-4 adults recruited from their brood-year escapement. Survival rates to compute recruitment will be those implied by the Ricker spawner / recruit function for each population.

The ceiling exploitation rates defined in this plan, which are intended to maximize long-term harvestable numbers and prevent extinction for the Skagit spring and summer/fall management units separately, are consistent with a “no jeopardy” ruling. The jeopardy standards themselves were explicitly used to calculate those rates, and the calculated ceiling rates are comparable to the rates on Skagit summer/fall chinook that were evaluated and approved in the Northern Fisheries Biological Opinion (NMFS 2000), which, depending on abundance, ranged from about 50 to 70 percent. Additional conservatism, beyond that evaluated in the Northern BO, is also provided. Low abundance threshold escapement levels, below which additional actions would be required, are established for both the spring and summer/fall chinook management units separately, and for each of the three summer/fall populations proposed in WDFW & WWTIT (1994). If it is decided that this management unit is composed of only one population, then the corresponding population-specific escapement thresholds can be deleted from this plan. Regardless, the intent of this plan is to take actions that prevent extinction of individual populations, while maximizing long-term harvestable numbers and achieving ESA jeopardy standards for the two Skagit wild chinook management units

During pre-season fishery planning, the impacts from a proposed fisheries management regime will be simulated, and escapement projected, based on the forecast abundance of all contributing chinook units (including those from British Columbia, the Washington coast, and the Columbia River, as well as those from Puget Sound). If the projected escapement of either management unit, or of any Skagit summer/fall stock falls below the low abundance threshold, further management actions will be triggered to reduce fishing mortality, as described in Appendix C. The FRAM fisheries simulation model, which is currently in use, estimates escapement for the Skagit summer/fall management unit, but that management unit total may be resolved into component stocks in proportion to their forecasted total abundance.

An analysis of how this regime would have functioned if it had been applied in previous years indicates that the exploitation rates would generally have been significantly lower than observed, and that the Appendix C provision would have been triggered in two of the recent years (R. Hayman, Skagit System Cooperative pers comm.)

Data gaps

Priorities for filling data gaps to improve understanding of stock / recruit functions or population dynamics simulations necessary to testing and refining harvest management objectives include:

- Consistent release of coded-wire tagged fingerling summer and fall chinook to enable direct assessment of harvest distribution, and estimation of harvest exploitation rates and marine survival rates;.
- Estimates of natural-origin smolt abundance from spring chinook production areas.
- Estimates of estuarine and early-marine survival for fingerling and yearling smolts.
- Limiting factors on yearling chinook abundance.

13.3 Stillaguamish River Management Unit Status Profile

Component Stocks

Stillaguamish summer chinook
Stillaguamish fall chinook

Geographic description

The Stillaguamish River management unit includes summer and fall stocks which are distinguished by differences in their spawning distribution, migration and spawning timing, and genetic characteristics. The summer stock, a composite of natural and hatchery-origin supplemental production, spawns in the North Fork, as far upstream as RM 34.4 but primarily between RM 14.3 and 30.0, and in the lower Boulder River and Squire Creek. Spawning also occurs in French, Deer, and Grant creeks, particularly when flows are high. The fall stock, which is not enhanced or supplemented by hatchery production, spawns throughout the South Fork and the mainstem of the Stillaguamish River (WDF et al 1993), and in Jim Creek, Pilchuck Creek, and lower Canyon Creek. Despite the small overlap in spawning distribution, it is likely that the two stocks are genetically distinct.

Allozmye analysis of the summer stock show it to be most closely related to spring and summer chinook stocks from North Puget Sound, and the the Skagit River summer stocks in particular.
The fall stocks align most closely with South Sound MAL, which includes Green River falls and Snohomish River summer and falls.

Life History Traits

Summer run adult enter the river from May through August. Spawning begins in late August, peaks in mid-September, and continues past mid-October. Fall chinook enter the river much later – in August and September. The peak of spawning of the fall stock occurs in early to mid-October, about three weeks later than the peak for the summer stock. The age composition of mature Stillaguamish River summer chinook, based on scales collected from 1985 – 1991 was as follows: 4.9% age-2, 31.9% age-3, 54.7% age-4, and 8.5% age-6 (WDF 1993 cited in HGMP).

Juvenile summer chinook produced in the Stillaguamish River primarily (95%) emigrate as sub-yearlings (WDF 1993 cited in HGMP).

Status

WDF et al. (1993) classified both the summer and fall stocks as depressed, due to chronically low escapement. Degraded spawning and rearing habitat currently limit the productivity of chinook in the Stillaguamish River system (PFMC 1997). After analyzing the trends in spawning escapement through 1996, the PSC Chinook Technical Committee concluded that the stock was not rebuilding toward its escapement objective (CTC 1999).

Aggregate spawning escapement for Stillaguamish summer/fall chinook has averaged 1,174 (geometric mean) over the period 1995 – 1999. From 1988 through 1995 escapement ranged from 700 to 950 (except 1991), and since 1995 has ranged from 1000 to 1500. The geometric mean of escapement in the last three years (1997-1999) was 1251, which was higher than the mean of 953 from the preceding five years (Myers et al 1998). From 1985 – 1991 the average escapements of summer and fall chinook were 879 and 145, respectively (WDF et al 1993). In the last five years (1996-1999) escapement to the South Fork averaged 229 (range 176 – 253), while escapement to the North Fork (exclusive of removed brood stock) ranged from 950 to 1540 (1994 – 1998). Escapement to the North Fork has comprised an average of 67% of total escapement since 1988 (Rawson 2000).

Table 1. Spawning escapement of Stillaguamish summer/fall chinook, 1990-1999.

	1990	1991	1991	1993	1994	1995	1996	1997	1998	1999
North Fork	575	1331	486	583	667	599	993	930	1292	845
South Fork	196	128	153	136	96	176	251	226	248	253
Total	842	1632	780	928	954	822	1380	1160	1544	1098

The total annual abundance of Stillaguamish summer/fall chinook for the period 1979 – 1995, estimated as potential escapement (i.e. the number of chinook that would have escaped to spawn absent fishing mortality), ranged from 1,300 to 2,500 without showing a clear positive or negative trend (PSSSRG 1997). However, the productivity, as indexed by the trend in MSY exploitation rate, declined substantially through this period.

The summer chinook supplementation program, which collects broodstock from the North Fork return, was initiated in 1986 as a Pacific salmon Treaty indicator stock program, and its current objective is to release 200,000 tagged fingerling smolts per year. Most releases are into the North Fork, via acclimation sites; relatively small numbers of smolts have been released into the South Fork. This supplementation program is considered essential to the recovery of the stock, so these fish are included in the listed ESU. The program contributes substantially to spawning escapement in the North Fork.

Harvest distribution

Stillaguamish chinook are harvested by coastal fisheries in Southeast Alaska, British Columbia, and Washington, as well as inside Puget Sound. Their harvest distribution is described from recoveries of coded-wire tagged summer chinook from the North Fork. The average distribution of total fishing mortality, derived from recoveries in 1991 – 1996, indicates that 2.6% of catch occurs in Alaska, 8.6% in northcentral B.C, 14.3% on the west coast of Vancouver Island, 17.3% in Georgia Strait, and 10.5% in other Canadian sport and net fisheries. Washington troll fisheries harvest 5.1%, net fisheries harvest 7%, and sport fisheries 34.7% of the total catch of Stillaguamish chinook. Annual harvest distribution has shown substantial variability, with notable recent declines in the proportion of total recoveries in the west coast Vancouver Island troll and Puget Sound net fisheries (CTC 1999).

A more recent analysis of coded-wire tag recoveries indicates that, for brood years 1991-94, exploitation rates have increased in Southeast Alaska, an declined in Canadian, Washington coastal, and Puget Sound fisheries (Table 2).

Table 2. The distribution of adult equivalent exploitation rates of Stillaguamish River summer chinook (CTC analysis cited in NMFS 2000).

Brood years	Total	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	.67	0	.31	.07	.29
1991-94 avg	.48	.06	.25	.01	.17

Exploitation rate trends:

Fishery exploitation rates for Stillaguamish summer chinook have been calculated for brood years 1986 – 1993, based on CWT recoveries. Systematic sampling of the spawning escapement in the North Fork for tagged adults enabled computation of the nominal exploitation rate as the expanded tag recoveries from all fisheries divided by the sum of expanded fishery and escapement tag recoveries. Fishery-related mortality of sub-adult chinook was adjusted for adult equivalency, according to methods standardized by the PSC Chinook Technical Committee. For these eight recent brood years, for which tag recovery of all year classes is complete, the adult equivalent fishery exploitation rate has ranged from 38 per cent to 66 percent (Table 3). Total exploitation rate has declined to an average of 48 percent for this period, compared with an average of 67 percent for the preceding four brood years (Table 2).

Table 3. Total fishery-related AEQ exploitation rate of Stillaguamish summer chinook for brood years 1986 – 1994 (from Rawson 2000).

1986	1987	1988	1989	1990	1991	1992	1993	1994
0.665	0.456	0.643	0.82	0.665	0.533	0.379	0.498	

Management Objectives

The management guidelines for Stillaguamish chinook include an exploitation rate objective and a critical escapement threshold. The exploitation rate objective is the maximum fraction of the production from any brood year that is allowed to be removed by all sources of fishery-related mortality, including direct take, incidental take, and non-landed mortality. The exploitation rate is expressed as an adult equivalent rate, in which the mortality of immature chinook is discounted relative to their potential survival to maturity.

The critical escapement threshold is 500 natural-origin spawners. Reconstruction of the total brood abundance of adult Stillaguamish chinook suggests that escapements of 500 (+/- 50) can result in recruitment rates ranging from two to five adults per spawner (Rawson 2000). The genetic integrity of the stock may be at risk and depensatory mortality factors may affect the stock when annual escapement falls below this threshold to 200 (NMFS BO 2000). Whenever spawning escapement is projected to be below this level, fisheries will be managed to achieve a lower rate than the interim exploitation rate objective.

Analysis specific to Stillaguamish summer chinook was completed to develop the exploitation rate objective to reflect, to the extent possible, the current productivity of the stock. Brood year recruitment (i.e., number of recruits per spawner) was estimated, for brood years 1986 through 1993, by reconstructing the total abundance of natural origin chinook that were harvested or otherwise killed by fisheries, or escaped to spawn. The resulting brood year recruitment rates were partitioned into freshwater and marine survival rates. The future abundance (i.e. catch and escapement) of the stock was simulated for 25 years, using a simple population dynamics model, under total fishery exploitation rates that ranged from 5 percent to 60 percent. In the model, production from each year's escapement was subjected to randomly selected levels of freshwater and marine survival, and randomly selected levels of management error. Each model run (i.e. for each level of exploitation rate) was replicated one thousand times, and the set of projected population abundances analyzed to determine the probability of achieving the management objectives. The simulation for Stillaguamish summer chinook, across a range of exploitation rates (Table 3), indicated that total exploitation rates below 0.35 met the recovery criteria.

Table 3. Summary of results of 1,000 runs of the simulation model at each exploitation rate.

Exploitation Rate	Probability of Falling below critical	Probability of recovery	Median Escapement ratio	Median Escapement
0.00	1%	96%	2.75	3,597
0.05	1%	96%	2.81	3,377
0.10	1%	96%	2.76	3,165
0.15	2%	95%	2.66	2,964
0.20	2%	95%	2.56	2,758
0.25	3%	93%	2.57	2,418
0.30	4%	92%	2.48	2,210
0.35	6%	92%	2.46	1,920
0.40	7%	91%	2.29	1,686
0.45	11%	87%	2.14	1,444
0.50	17%	80%	1.92	1,180
0.60	41%	52%	1.04	648
0.70	73%	12%	0.27	259
0.80	94%	0%	0.02	55

The fishery management objectives for the 2000 management year was to realize an exploitation rate that, if imposed consistently over a future time interval

- would not increase the probability that the stock abundance would fall below the critical escapement threshold, after 25 years, by more than five percentage points higher than were no fishing mortality to occur; and

- would result in at least an 80 percent of greater probability of the stock recovering (i.e. escapement exceeding the current level) after 25 years.

Stock recovery, for this analysis, was defined as the average spawning escapement for the final three years in the simulation period exceeding the average for the first three years in the simulation period (Rawson 2000).

At the present time, there is very little information concerning the productivity of the Stillaguamish fall stock other than the fact that the average abundance of this stock has been approximately 50% of the Stillaguamish summer stock based on relative escapement. Incorporating this lower estimate of abundance, and assuming the same productivity (i.e. recruitment rates), the simulation model predicted that exploitation rates below 35% met the first management objective. The probability of rebuilding at this exploitation rate was 96%. This analysis indicates that a target exploitation rate of 0.35 would also be appropriate for the Stillaguamish fall stock.

The Washington co-managers have set an exploitation rate guideline of 0.25, as estimated by the FRAM simulation model, for the Stillaguamish chinook management unit. According to the simulation model this level of exploitation results in a 4 percent risk of the stocks falling below the critical escapement threshold of 500, and affords a 92 percent probability of recovery (i.e., that spawning escapement will exceed the current average level).

Data gaps

Priorities for filling data gaps to improve understanding of stock / recruit functions or population dynamics simulations necessary to testing and refining harvest management objectives include:

- Spawning escapement estimates that include variance for summer and fall stocks
- Estimates of natural-origin smolt production (freshwater survival to the estuary)

13.4 Snohomish River Management Unit Status Profile

Component Stocks

Summer/fall chinook management unit

Skykomish
Wallace River
Snoqualmie
Bridal Veil

Geographic description

Snohomish summer chinook spawn in the mainstem of the Snohomish River and Skykomish River, and in tributaries to these rivers. Relative to spawning distribution in the 1950's, a much larger proportion of summer chinook currently spawn higher in the drainage, between Sultan and the forks of the Skykomish (SBSRTC 1999).

Bridal Veil fall chinook spawn in Bridal Veil Creek, the South Fork of the Skykomish between RM 49.6 and RM 51.1 and above Sunset Falls (fish have been transported around the falls since 1958), and the North Fork up to Bear Creek Falls (RM 13.1). There is some indication that spawning in the North Fork has declined over the last twenty years (SBSRTC 1999).

Snoqualmie fall chinook spawn in the Snoqualmie River and its tributaries, including the Tolt River, Raging River, and Tokul Creek).

The summer/fall stock spawning in the Wallace River is mixture of natural-origin fish with returns to the Wallace River Hatchery (the only hatchery facility that currently releases chinook into the Snohomish River system). These hatchery fish stray to other areas in the Skykomish River, and may mix with Snohomish summer chinook. (WDF et al 1993). Broodstock collection was changed in brood year 1997 to exclude fall chinook, and thus reduce the influence of out-of-basin stocks on production.

There is some uncertainty whether a spring chinook stock once existed in the Snohomish system. Suitable habitat may still exist in the upper North Fork, above Bear Creek Falls.

The delineation of chinook populations within the Snohomish system is currently under review by the state and tribal comanagers and the Puget Sound Technical Recovery Team. Thus, the delineation described here may be modified in the near future. If this occurs, the analyses upon which the current management objectives are based will be redone based on the new population delineation. Depending upon the results of this analysis, the management objectives may or may not be changed.

Life History Traits

Summer chinook enter freshwater from May through July, and spawn, primarily, in September, while fall chinook spawn from late September through October. However, fall chinook spawning in the Snoqualmie River continues through November. The peak of spawning for Bridal Veil chinook is in the second week of October (i.e. slightly later than the peak for fish spawning in the mainstem of the Skykomish. Natural spawning in the Wallace River occurs throughout September and October (WDF et al 1993).

The age composition of returning Snoqualmie River fall chinook showed a relatively strong age-5 component (28 percent), relative to other Puget Sound fall stocks. Age-3 and age-4 fish comprised 20 and 46 percent, respectively, of returns in 1993 – 1994 (WDFW 1995 cited in Myers et al 1998).

Most Snohomish summer and fall chinook smolts emigrate as underyearlings, but, based on limited scale data, an annually variable, but relatively large, proportion of smolts are yearlings. Of the summer chinook smolts sampled in 1993 and 1994, 33 percent were yearlings (WDFW 1995 cited in Myers et al 1998). Based on scale data, 25 to 30 percent of returning fall chinook also showed a stream-type life history (SBSRTC 1999). No other summer or fall chinook stocks in Puget Sound produces this high a proportion of yearling smolts. Rearing habitat to support yearling smolt life history is vitally important recovering this stock.

Management Unit / Stock Status

Total natural spawning escapement of Snohomish summer/fall stocks has ranged between 2,700 and 6,300 over the last ten years, and has exceeded the nominal escapement goal of 5,250 only twice, in 1998 and 2000(Table 1). However, due in part to reduced exploitation rate, escapement has, since 1996, rebounded from the levels less than 4,000 observed in the early 1990's. Escapement of the summer stock was below 1,000 through most of the 1990's, and fell to an historic low of 263 in 1997. In contrast, escapement of chinook in the Snohomish and Snoqualmie rivers has increased in recent years, with natural-origin fish comprising more than 90% of the fish on the spawning grounds. Escapement of the Bridal Veil stock, however, has declined, based on counts at Sunset Falls (SBSRTC 1999). Returns to Wallace River have also declined to an average of less than 500. Otolith analysis indicates that 60 percent of the natural spawners in 1997 were hatchery-origin fish (SBSRTC 1999).

Table 1. Spawning escapement of Snohomish summer/fall chinook, 1990-2000.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4,209	2,783	2,708	3,866	3,626	3,707	4,850	4,300	6,306	4,799	6,092

Harvest distribution and exploitation rate trends:

The harvest distribution and exploitation rate for Snohomish summer/fall chinook have been assessed, however lack of representative tagged production from this Snohomish system has necessitated basing the analysis on the chinook harvest model used by the Chinook Technical Committee of the Pacific Salmon Commission. This analysis indicates that total exploitation rate has declined more than fifty twenty percentage points from levels for brood years in the late 1970's (Table 2). Recent exploitation rates have likely declined further due to restrictions of Canadian and Washington mixed stock fisheries.

Table 2. Total fishery-related, adult equivalent exploitation rates of Snohomish summer/fall chinook for brood years 1979 – 1994 (Del Simmons, Chinook Tech Comm pers. comm.)

Brood Year	AEQ ER
1979	0.78
1980	0.75
1981	0.71
1982	0.66
1983	0.62
1984	0.63
1985	0.67
1986	0.66
1987	0.64
1988	0.59
1989	0.54
1990	0.54
1991	0.55
1992	0.47
1993	0.27
1994	0.21

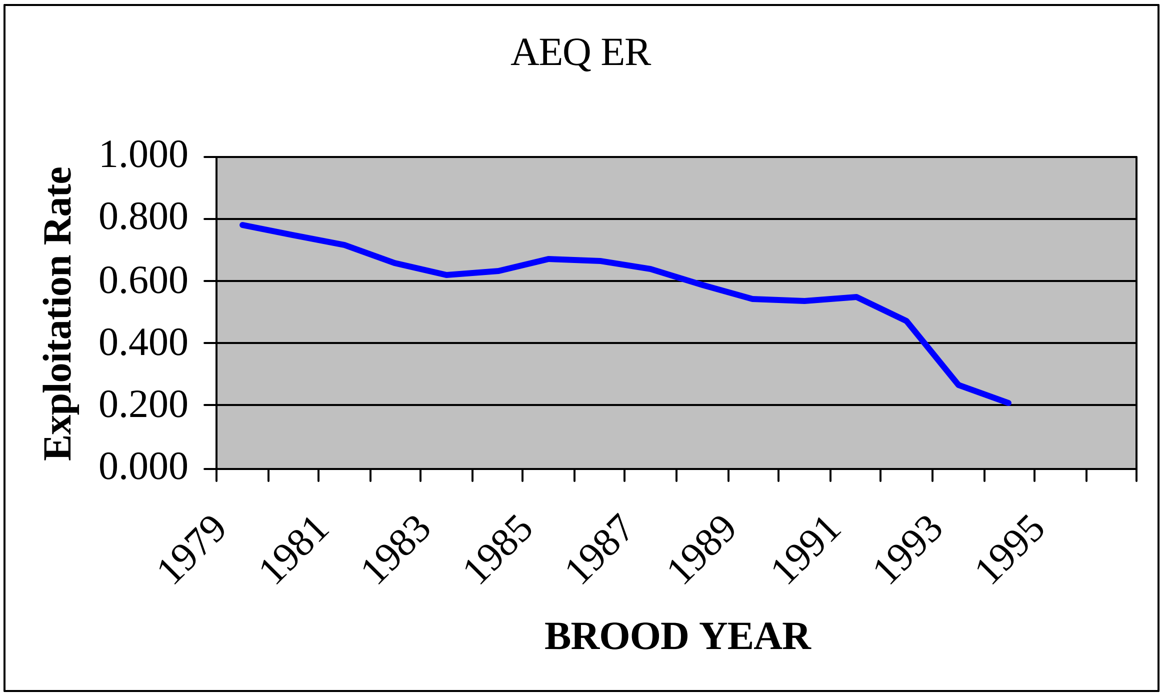


Figure A-1. Adult equivalent total exploitation rate of Snohomish River chinook, brood years1980 – 1996.

Until recently, harvest-related mortality occurred predominantly in fisheries in British Columbia, and Puget Sound sport fisheries accounted for 23 percent of the total mortality. The stocks are not intercepted in significant numbers in fisheries on the Washington coast that are under the purview of the Pacific Fisheries Management Council.

Table 3. Harvest distribution of Snohomish summer/fall chinook – average of brood years 1980 – 1986 (PSSSRG 1992).

Brood years	Alaska	B.C.	PFMC	Puget Sound troll	North Puget Snd net	Other Puget Sound net	Puget Sound sport
1980-86 avg	4.6%	59.3%	0%	2.2%	2.0%	8.3%	23.5%

Through this same period, the total production of Snohomish chinook was declining steadily. The potential escapement, which represents the annual abundance (catch plus escapement) fell from 25,000 in 1980 to about 6,000 in the early 1990's. Increasingly constrained fishing failed to reverse this trend, which has been attributed to declining freshwater and marine survival (PSSSRG 1997, WDF et al 1993). The SASSI review concluded that Snohomish summer and fall stocks were depressed, that the Wallace River stock was healthy, and that the status of the Bridal Veil fall stock was unknown (WDF et al 1993).

Management Objectives

Management objectives for Snohomish summer/fall chinook include an upper limit on total exploitation rate, to insure that harvest does not impede the recovery of the component stocks, and a critical threshold for spawning escapement to maintain the viability of the stocks.

Fisheries in Washington will be managed to achieve a total, adult equivalent exploitation rate, associated with all coastal fisheries, not to exceed 32 percent.

Lacking direct information on the extent to which the current fisheries regime may disproportionately harvest any single stock, the spawning escapement of each stock will be carefully monitored for indications of harvest impact. Average escapement during the period of 1965 – 1976 will be the benchmark for this monitoring (SMSRTC 1999).

The Puget Sound Salmon Management Plan (1985) mandated that fisheries will be managed to achieve maximum sustainable harvest (MSH) for all primary natural management units. The recovery exploitation rate is likely to be lower than the rate associated with MSH under current conditions of productivity. The conservatism implied by the recovery exploitation rate imbues caution against the potential size and age selectivity of fisheries, and the effects of that selectivity on reproductive potential, and potential uncertainty and error in management.

Low Escapement Threshold for Management

A low escapement threshold of 2,000 spawners (natural origin, naturally spawning fish) for the management unit is established as a reference for pre-season harvest planning. If escapement is projected to fall below this threshold under a proposed fishing regime, extraordinary measures will be adopted to minimize harvest mortality. Directed harvest of Snohomish natural origin chinook stocks, (e.g., net and sport fisheries in the Snohomish terminal area or in the river) has already been eliminated in Washington. Further constraint, thus, depends on measures that reduce incidental take.

The low escapement threshold for the management unit was derived from critical escapement thresholds for each of the Snoqualmie, Skykomish, and Bridal Veil populations in a two step process. First, for each population, the critical escapement threshold was expanded to a critical level for management according to the following formula

$$E_{man,p} = E_{crit,p} / [(R/S)_{low,p} * (1-RER_{mu})]$$

Where $E_{man,p}$ is the lower management threshold for population ***p;***

$E_{crit,p}$ is the critical threshold for population *p;*

$R/S_{low,p}$ is the average of recruits/spawner for population ***p*** under low survival conditions; and

RER_{mu} is the RER established for the management unit

The following describes the $\boldsymbol{E_{man,p}}$ for the Snoqualmie, Skykomish and Bridal Veil populations within the Snohomish management unit. Information was insufficient to derive these quantities for the Wallace population.

The following analysis is based on estimates of natural spawning escapement to the Snohomish system, by population, for the past decade.

Table 4. Estimated natural escapement per population for Snohomish chinook 1990-2000 from WDFW spawner surveys.

	Snoqualmie	Skykomish	Wallace	Bridal Veil
1990	1277	2031	370	613
1991	591	1459	200	603
1992	706	867	203	612
1993	2213	959	109	630
1994	728	1391	468	564
1995	385	1321	280	1036
1996	1032	1931	713	860
1997	1937	773	713	744
1998	1892	1916	1543	572
1999	1344	1301	1280	722
2000	1427	957	2550	1161
average	1230	1355	766	738
average %	30.1%	33.1%	18.7%	18.0%

Based on three years of data from intensive sampling of chinook carcasses in the Snohomish system for thermally marked otoliths from local hatcheries, it is possible to estimate the natural origin component of each of the escapement estimates in Table 4 (K. Rawson, unpublished data and analysis). These estimates are reproduced below in Table 5. The estimates in Table 5 are likely to be modified once additional years of otolith samples are available and they certainly will be modified if the population delineation of chinook salmon in the Snohomish system is revised.

Table 5. Estimated natural origin (NOR) escapement for three populations of Snohomish chinook salmon based on estimates of hatchery contribution to natural spawning populations in 1997, 1998, and 1999 (K. Rawson, unpublished data and analysis).

	Estimated NOR Escapement		
	Skyk.	Bridal V	Snoq.
1990	1,902	533	1,104
1991	1,384	556	459
1992	762	547	603
1993	777	518	2,091
1994	1,009	331	563
1995	903	780	115
1996	1,368	515	664
1997	755	524	1,813
1998	789	115	1,424
1999	696	444	1,049

Snoqualmie

The critical threshold was set at 400 natural origin recruit spawners. The smallest value for estimated NOR spawners in this system since 1990 (Table 5) is only 115. However, it is likely that spawner survey conditions were very poor in 1995 due to high flows during the chinook spawning season and the flashy pattern of flows (C. Kraemer, WDFW, personal communication). Therefore, the spawning escapement estimate for the Snoqualmie is considered to be an extreme underestimate. We chose a value of 400 as a low level of NOR spawners that has produced positive returns in the past and is in excess of the VSP recommended level. The low escapement threshold for management purposes was derived by the same method used for the Stillaguamish summers (Rawson 2000):

$$\frac{E_{crit}}{(R/S)_{low}} = \frac{400}{(1.01)*(1-0.32)} = 582$$

The average lowest R/S was 1.01 (1987, 1990-1992) and the exploitation rate objective is 32% (see below). The low R/S buffers against years of low productivity and the exploitation rate objective buffers against escapements falling below the critical escapement threshold under the maximum allowable exploitation rate regime.

Skykomish

The critical threshold was set at 300 natural origin recruits based on the VSP guidelines and comparisons with the Stillaguamish system (322). Escapements since 1990 have generally been higher than what would be considered critical (range = 696-1,902). The median total natural escapement has been 1,321 (789 NOR). The low escapement threshold for management purposes was set at 621, using the method described above for the Snoqualmie. The average lowest R/S was 0.71, and the exploitation rate objective was again 32%.

Bridal Veil

Bridal Veil is generally the smallest component of the Snohomish management unit. Lacking better population-specific information, the critical escapement threshold is proposed to be 200 based on VSP guidelines. The low escapement threshold was derived as described above, using an average lowest R/S of 0.9 and an exploitation rate objective of 32%. The resulting low escapement threshold was 327 natural origin recruit spawners.

The second step in deriving the management unit lower threshold was to expand each population's lower management threshold by dividing by the percentage of the total escapement that the population in question is expected to comprise.

Using the information in Table 4, we can compute the total system escapement required such that we expect each management unit to achieve its lower escapement management threshold by dividing the population lower threshold by its average proportion of the total natural escapement as summarized in the following table:

Table 6. Derivation of the lower management threshold for each Snohomish chinook population and the management unit escapement necessary to achieve this level for each population.

	Snoq	Skyk	Wallace	Bridal V
Critical level	400	300	NA	200
Low R/S	1.01	0.71		0.9
Exp. rate	0.32	0.32		0.32
Low threshold	582	621		327
Implied MU LT	1,936	1,875		1,811

The management unit lower thresholds required to achieve the lower thresholds for the three populations of interest are all near, and below, 2,000. So, a value of 2,000 was chosen as the management unit lower threshold for management planning purposes. Based on the average percentage contributions of each population to the entire escapement, this level provides the greatest cushion to the Bridal Veil population, which is the smallest one.

Maximum Exploitation Rate Guideline

The maximum exploitation rate guideline for the Snohomish chinook management unit has been set at 0.32. This value is based on stochastic simulation modeling of recruitment and escapement for the Snoqualmie and Skykomish populations over 25-year time horizons. Simulations were based on spawner-recruit relationships derived from recent data on escapement and recruitment. Because there are no direct estimates of exploitation rates available from coded-wire tags for this system, recruitment estimates were based on exploitation rates derived form the model used by the Chinook Technical

Committee of the Pacific Salmon Commission (Table 2). The stochastic simulation modeling incorporated random variation due to deviation from the fitted spawner/recruit relationships, variation in marine survival, and management error. The general marine survival regime assumed in the modeling was based on observed marine survivals for the 1983 to 1992 brood years, which has been a period of relatively low marine survival compared to historical experience.

Simulations were performed at a series of exploitation rates ranging from 0 up to 0.60. The 25-year simulations were repeated 2,000 times at each exploitation rate modeled. The results of the simulations were tallied to determine 1) the fraction of years that the escapement fell below the critical threshold (400 for the Snoqualmie and 300 for the Skykomish) and 2) the fraction of simulation for which the final 4-year geometric average escapement exceeded an upper threshold. The upper threshold was based on a computation of the escapement that would produce maximum sustainable harvest under current conditions of productivity. The exact value of the upper threshold depended upon the parameters of the assumed recruit relationship.

Acceptable maximum exploitation rates were those that produced a probability of greater than 95% of exceeding the critical threshold escapement and a probability of greater than 80% of the final four-year geometric average escapement in a 25-year simulation exceeding the upper threshold. For the Snoqualmie simulations, all exploitation rates of 0.32 or smaller met both of these criteria. For the Skykomish simulations, all exploitation rates of 0.34 or smaller met both criteria.

K. Rawson, Tulalip Tribes, and N. Sands, NMFS, are currently developing further written documentation of these analyses.

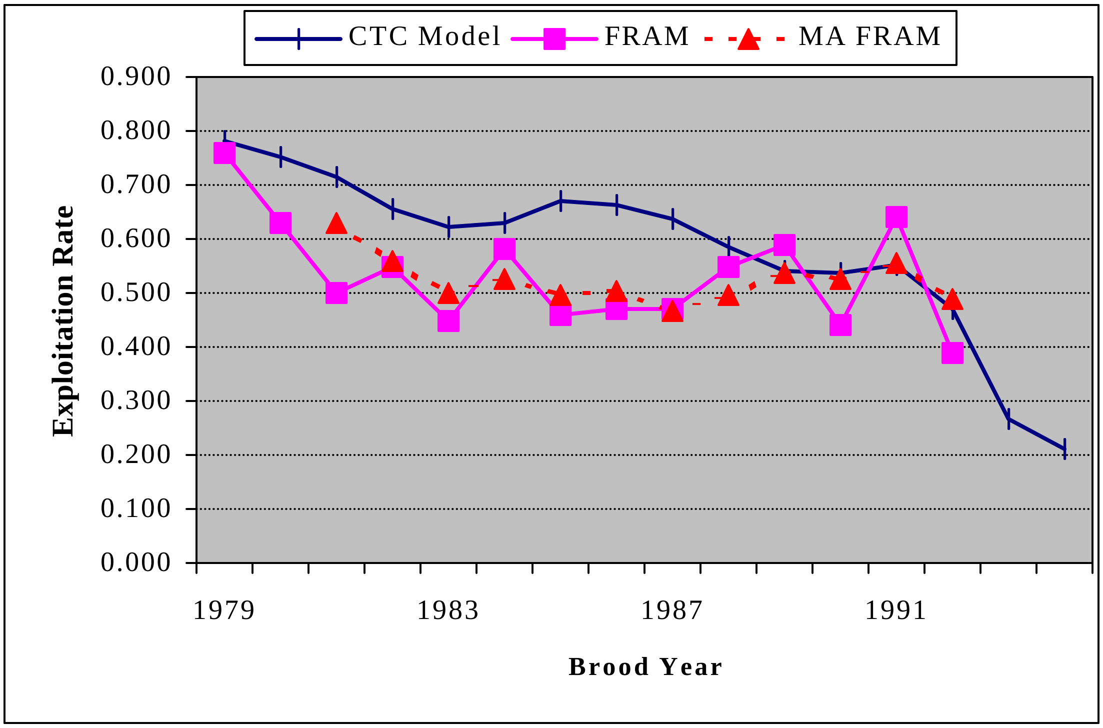
Rationale for management of aggregated stocks

The management unit maximum exploitation rate was set at 0.32, which is the lower of the maximum allowable rates computed for the Snoqualmie and Skykomish populations. This is assumed to provide the appropriate protection to all populations segments within the system.

The lower escapement threshold for management was set according to the procedure described above, which starts with critical escapement levels, expands these to per population management thresholds, and expands again to a management unit threshold based on the average contribution of each population to the management unit's escapement. This approach should provide more than adequate protection to each component population.

Interpretation of FRAM model for preseason planning

Currently the comanagers use the Fishery regulation Assessment Model (FRAM) for preseason planning of total fishery impacts. This model assesses exploitation rates over all coastal fisheries impacting the Snohomish management unit from Alaska to California. Dell Simmons of NMFS has provided data from which the following graph was constructed comparing the estimate of exploitation rate on the Snohomish management unit using the CTC model (Table 2) to the rate estimated by FRAM



(postseason run of the FRAM model).

On average, the FRAM estimates are smaller than the CTC estimates from which the management guidelines proposed here were developed. Ordinarily, this relationship would indicate an upward adjustment in the FRAM number to achieve a given guideline as developed using the CTC data (for example, we might use an upper guideline of 0.35 from FRAM as equivalent to our 0.32 guideline based on the CTC data). However, since the exploitation rates have declined greatly in recent years, the relationship between the FRAM and CTC rates might be changing. Also, the FRAM and CTC rates in the above graph are not directly comparable, since the CTC rates are based on brood years, while the FRAM rates are based on fishing years. To adjust for this difference, the three-year moving average of the FRAM rate is graphed as a dashed line in the figure. Although this line falls below the CTC line for most years in the series, it matches the CTC line nearly exactly for the four most recent years available. Therefore, we have chosen to make no adjustment for the exploitation rate as estimated by FRAM, and, for now, the 0.32 maximum exploitation rate guideline will apply to the preseason output from FRAM. In the future we will continue to compare the postseason FRAM estimates of exploitation rates to estimates from the CTC model and modify the FRAM adjustment as appropriate.

Data gaps

Priorities for filling data gaps to improve understanding of stock / recruit functions, harvest exploitation rate, and marine survival:

- Annual implementation of a double-index coded-wire tagging program using fingerling summer chinook from Wallace River Hatchery to enable direct assessment of harvest distribution, and estimation of harvest exploitation rates and marine survival rates. (Initiated beginning with the 2000 brood year).

- Estimates of natural-origin smolt abundance from chinook production areas. (Smolt trapping began in the Skykomish in 2000 and will begin in the Snoqualmie in 2001).

- Estimates of estuarine and early-marine survival for fingerling and yearling smolts.

- Quantification of the contribution of hatchery-origin adults to natural spawning for each stock. (Research is underway. Estimates of hatchery contribution to natural spawning populations will be available for the 1997 through 2001 return years.)

13.5 Lake Washington Management Unit Status Profile

Component Stocks

Cedar River fall chinook
Sammamish River tributaries fall chinook
North Lake Washington tributaries all chinook

Geographic description

Fall chinook are produced in three basins in the Lake Washington watershed, the Cedar River, Big Bear Creek and its tributary Cottage Creek (the "Northern Tributaries" which are tributaries of the Sammamish Slough), and Issaquah Creek. Historically, chinook also spawned in other smaller tributaries to Lake Washington (e.g. – May and Kelsey creeks) and the Sammamish Slough, (e.g. Little Bear, Swamp, and North creeks), and field studies are in progress to quantify their current use of these streams. Adults that return to Issaquah Creek are presumed to be predominately of hatchery origin. Genetic samples from chinook in Bear/Cottage Creek are similar to those from Issaquah Creek. It is not clear whether the introgression of hatchery genetics into Bear/Cottage is historical or ongoing.

Chinook enter Lake Washington drainages from late May through early November, and spawning is usually complete by the end of November. About ten miles of Bear Creek, and three miles of Cottage Creek, are accessible to chinook. Recent surveys have located concentrated spawning between RM 4.25 and 8.75 in Bear Creek and the entire three miles of Cottage Lake Creek. Spawning in Issaquah Creek occurs predominately in reaches between RM 1 and the Issaquah hatchery (Ames et al 1975). Chinook surplus to hatchery needs are sometimes passed upstream of the rack and spawn in Issaquah Creek. In the Cedar River, access above RM 21 is blocked by the Landsburg diversion dam. Chinook spawning in the Cedar River is concentrated between RM 4.0 and 19.0.

Allozyme analysis of samples collected from Cedar River chinook suggest that this stock is genetically distinct, but closely related to that in the Green River. Green River hatchery fish were outplanted into the Cedar River system from 1952 to 1964. Until 1916 the Cedar River drained into the Green River, so a close relationship is not surprising. Sampling and genetic analysis of returns to the Sammamish River and other independent tributaries is in progress, and preliminary analysis suggests that chinook in Bear/Cottage Creek have similar genetics to those chinook spawning naturally in Issaquah Creek. Outplants were made to most of the tributaries to the Lake Washington basin from the Issaquah and Green River hatcheries, from the period of record (1952 on). Most of these plants have continued through at least the early 1990s. The one exception is the Cedar River where the last plants were in 1964.

Life History Traits

Juvenile outmigration trapping in the Cedar River has shown that the outmigrant is bimodal with most of the fish entering the lake prior to April as fry. A smaller percentage of these fish rear in the river to smolt size and outmigrate between May and July. In 1999, approximately 75% of the outmigrants were fry. These fry rear along the lakeshore, growing quickly and leaving the lake as zero-age smolts. The smolts that migrate out of the river are thought to reach the Locks about the same time as the fry, although some fish are still migrating out of the river in late July. The migration through the Locks begins in mid-May and continues until at least September. Recent PIT tagging of Cedar River chinook suggests that the Cedar River fish migrate out later in the season than hatchery chinook. The Cedar River chinook fry that rear along the lakeshore are unique in that most, if not all, of the chinook stocks that use a lake for rearing are age one or two smolts. The Lake Washington stocks also have a protracted smolt outmigration, with a large percentage of the run outmigrating after July 1.

Table 5. Age composition data collected for fall chinook during 1998 in Big Bear Creek and Issaquah Hatchery (Carasco et al 1998).

	Issaquah Creek		Big Bear Creek		
Age	Male	Female	Male	Female	blank
2	0	0	2	0	
3	19	6	29	9	
4	69	66	17	14	2
5	2	17	0	1	
6	0	1			
Unk			2		
total	90	90	50	24	2

Status

The SASSI assessment concluded that the status of the Cedar River stock was unknown, though there was evidence of a short-term decline in escapement in the late 1980's (WDF et al 1993 Appendix I). Escapement into the northern Lake Washington tributaries and the Sammamish River was not adequately quantified, so the status of these stocks were also unknown (WDF et al 1993 Appendix I). Escapement to the Cedar River has been consistently below the goal of 1,200 since 1974. The geometric mean of escapement from 1992 – 1996 was 377; for the three more recent years the mean has further declined to 287. This falls below the NMFS criterion for 'overfished' stocks, because it is less than half of the presumed MSY escapement of 1,200. Surveys of the Bear Creek system indicate that escapement has declined below 100, compared with an average of 300 that was seen in the 1980's (MIT et al 1999). In 1998 and 1999 the Bear Creek system has experienced increased escapement to a high of 537 fish in 1999. Directed terminal fisheries have been closed since 1994, and pre-terminal fishing mortality reduced by 50 percent since 1997, but spawning escapements in the Cedar remain near the critical threshold.

Table 1. Spawning escapement of Lake Washington fall chinook, 1990-1999 (MIT et al 1999).

	1990	1991	1991	1993	1994	1995	1996	1997	1998	1999
Cedar River	469	508	525	156	452	681	303	227	432	241
Bear Creek	318	153	265	89	436	249	25	67	265	537

Watersheds that drain into Lake Washington are among the most heavily developed in the Puget Sound. Spawning and rearing habitat required by chinook has been degraded by development of riparian corridors. Migration is constrained by barriers in the mainstem and in many tributaries, and the migration route through Lake Washington and Lake Union, and connecting waterways severely influenced by industrial and urban development**.**

Harvest distribution

The harvest distribution of Lake Washington chinook has not been directly assessed because representative coded-wire tagged hatchery releases are only available for a few brood years from the Issaquah Hatchery in the late 1980s, and the University of Washington hatchery in the late 90s. However, because of their similar life history and genetic heritage, tagged fingerling releases from the Soos Creek hatchery (Green River) facilities are thought to provide an accurate representation of pre-terminal harvest distribution. Based on analysis of tag recoveries from brood years 1991 – 1991, 30 percent of the total harvest mortality has occurred in Canadian fisheries, 5 percent in Washington coastal troll and recreational fisheries, and 65 percent in Puget Sound fisheries (unpublished CTC analysis cited in NMFS 2000). There is substantial annual variation in harvest distribution, with catch in the WCVI troll and Canadian net fisheries declining due to restriction of those fisheries in recent years.

Terminal harvest of Lake Washington chinook has been minimized in recent years by regulatory measures that have eliminated directed harvest and reduced incidental harvest in Shilshole Bay, the Ship Canal, and in Lake Washington. Commercial and recreational fisheries directed at sockeye and coho salmon have been specifically shaped to reduced impacts on chinook. Recreational fishing regulations are promulgated to focus effort on the Issaquah Hatchery returns. Monitoring of the return through Ballard Locks has, since 1994, provided in-season assessment of the abundance of chinook.

Exploitation rate trends

It is also assumed that the pre-terminal exploitation rate of Lake Washington chinook is similar to that of the Green River (i.e. the ‘South Sound fingerling’) indicator stock. The total exploitation rate of the Green River stock has fallen from an average of 73 percent for brood years 1977 – 1990, to 43 percent for brood years 1991 – 1994. This reduction is attributable to decreasing mortality in Canadian fisheries based on averages of the same brood year aggregates, from 25 percent to 13 percent, and in Puget Sound fisheries, from 37 percent to 28 percent (CTC unpublished data cited in NMFS 2000).

Management Objectives

The co-managers expect to manage impacts to Lake Washington natural chinook in all of the various fisheries throughout Puget Sound so as to constrain total exploitation rates in southern U. S. fisheries to a level within the range observed in recent years, e.g., 1998-2000. The co-managers will continue to employ management actions of recent years, which have limited impacts on Lake Washington natural chinook to very low incidental levels. The co-managers believe this harvest management plan will ensure harvest impacts are consistent with recovery of listed stocks. The co-managers also expect to further refine their harvest management plan for Lake Washington natural chinook within the next two years in light of on-going ESA recovery planning to ensure harvest impacts are consistent with recovery of listed stocks. During the next two years, if estimated impacts are predicted to exceed the range observed in recent years, the co-managers will meet and discuss what additional actions, if any, may be appropriate to bring the exploitation rate back within the range.

Fisheries will be managed to achieve an escapement 1,550 to Lake Washington streams, which will be determined by live counts in the Cedar River index reach of 1,200 chinook. As a general observation 22% of the natural run entering the lake, or 350 fish (if the Cedar has 1,200), will reach the Northern Tributaries.

Escapement goal management is retained for Lake Washington chinook in the terminal area because an inseason update (ISU) is possible to assess run strength inseason. The ISU is based on a count of adult passage at the Ballard Locks. Further, the alternative, management by exploitation rate, requires fundamental stock management data that is not currently available. Data is not available, for example, to expand index counts into a total estimate of escapement. Neither is the contribution of hatchery-origin fish to escapement in the northern tributaries quantified. The long-term objective for Lake Washington chinook is to increase production to the point that the escapement goal is regularly met or exceeded.

Lake Washington chinook are one of the weaker key stocks in the mix of chinook populations impacted by ongoing pre-terminal fisheries. Terminal fisheries have been closed for seven years, pre-terminal exploitation rates have been declining (cut in half since 1997), and in 1999 additional restrictions were imposed, yet the escapement index remains very near the critical level.

Underlying specific harvest management objectives is the need to maintain the diversity of naturally reproducing stocks that comprise the management unit. Diversity is manifest in several measurable qualities of the populations, including the age composition of mature fish, migration timing, spawning and rearing distribution, and genetic and phenotypic variation.

The impact of historic or current harvest management practices on population diversity of Lake Washington stocks has not been described. The potential effects of terminal harvest on diversity, due to age or size selectivity of fishing gear, are much reduced since directed fisheries have been closed since 1994.

The low abundance threshold is defined as spawning escapement of 200 in the Cedar River index reach. If pre-season fishery simulation modeling indicates that escapement will fall below this level, conservation measures will be implemented to reduce fisheries mortality to the level defined by modeling the fisheries regime detailed in Appendix C.

Data gaps

The highest priority will be placed on collecting the data needed to quantify the productivity of Lake Washington stocks. Until the fundamental aspects of productivity are defined it will be difficult to assess the success of recovery actions, whether they entail improvement in habitat productivity, production supplementation, or restriction of harvest.

Table 3. Data gaps related to harvest management, and projects required to address those data needs.

Data gap	Research needed
Estimates of total spawning escapement for each stock.	Mark/recapture study, repeated for a minimum of three years; or an alternate approach to expanding index reach counts to total escapement. First done in FY2000
Estimates of smolt production in Issaquah Creek.	Fry/smolt trapping in Issaquah Creek to supplement ongoing trapping in the Northern Tributaries and the Cedar River.
Quantification of fry and smolt survival in Lake Washington and the Ship Canal.	Smolt trapping at the locks to quantify mortality as smolts transit the lake and the locks. Expected to begin in 2001.
Quantification of freshwater predation on smolts	Continuation of the Lake Washington Studies Project to further quantify fish, bird and lamprey predation.
Comprehensive estimates of incidental fishing mortality.	Creel surveys of recreational fisheries that target other species. The approach should be research oriented.
Estimates of bias in ladder counts at Ballard Locks, relative to spawning ground surveys.	Tagging and tracking of adult chinook from the locks and the ladder to estimate repeat passage. Started in 1998.

Related Data Questions

Is chinook survival from emergent fry to adult (smolt?) correlated with early life history strategy? (i.e. – what are the relative survival rates of fry outmigrants compared to smolt outmigrants in the Cedar River).

Is scour of chinook redds related to the magnitude of peak flow events in the Cedar River, and the position of redds in the stream channel?

What is the relationship between flow at Landsburg and the availability of water at the Locks for operating the smolt slides?

13.6 Green River Management Unit Status Profile

Component Stocks

Green River fall chinook

Geographic description of spawner distribution

Fall chinook are produced in the mainstem Green River and in two major tributaries - Soos Creek and Newaukum Creek. Adults that spawn in Soos Creek are presumed to be predominantly of hatchery origin. However, recent investigations into straying raise questions regarding this, and other assumptions related to run reconstruction. (See stock status, below). Newaukum Creek spawners appear to be closely related to the spawners in the mainstem.

Spawning in the mainstem Green River occurs from RM 26.7 up to RM 61. Spawning access higher in the drainage is blocked by the City of Tacoma's diversion dam, and at RM 64 by Howard Hanson Dam. Spawning occurs in the lower 10 miles of Newaukum Creek. Adults returning to the hatchery at RM 0.7 of Soos Creek may also spawn naturally and adults surplus to program needs at the Soos Cr. Hatchery are often passed upstream.

Life History Traits

Fall chinook begin entering the Green River in July, and spawn from mid-September through October. Ocean-type freshwater life history typifies summer/fall stocks from South Puget Sound, with 99 percent of the smolts outmigrating in their first year (WDFW 1995 cited in Myers et al 1998). A long-term average of the age composition of adults returning to the Green River indicates the predominance of age-4 fish (62 percent), with age-3 and age-5 fish comprising 26 percent and 11 percent, respectively (WDF et al 1993, WDFW 1995 cited in Myers et al 1998).

Status

The SASSI review (WDF et al 1993) classified Green River chinook as healthy, because spawning escapement had consistently met the objective since 1978. Spawning escapement has increased recently, with the mean of the 1997 – 1999 (8721) exceeding that for the preceding five-year period (4799). Total escapement fell below the nominal goal of 5,500 in 1992 – 1994, which triggered an assessment of factors contributing to the escapement shortfall by the PFMC (PSSSRB 1997). However, escapement has exceeded the goal in each subsequent year.

Table 1. Spawning escapement of Green River fall chinook, 1990-1999.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
7,035	10,548	5,267	2,476	4,078	7,939	6,026	9,967	7,300	9,100

It is known, however, that returns from hatchery production contribute substantially to natural spawning in the Green River and tributaries, and viability of the naturally spawning stock, absent the hatchery contribution, is uncertain because hatchery returns may be masking poor natural productivity (Myers et al 1998). Analysis of coded wire tags recovered from the spawning grounds and the in-river fishery has yielded highly variable results.

The nominal escapement goal is based on approximate estimates of escapement in the 1970's, and may not reflect the productivity constraints associated with current degraded habitat, but will be used to guide fisheries management until natural capacity is better quantified. Escapement estimation methods are under review. Surveys have been expanded in recent years to calibrate assumptions regarding the relationship between index area counts and total escapement and the first year of a mark/recapture method, also for the purpose of calibration of escapement estimates, was just completed.

Hatchery facilities currently operate on Soos Creek and Icy Creek. Broodstock has always been collected from local returns, so the hatchery stock presumably retains its native genetic character. Allozyme analysis has not shown a difference between hatchery-reared and naturally spawning adults (WDFW unpublished data).

Harvest distribution and exploitation rate trends:

Exploitation rates for Green River chinook have declined substantially in recent years. Total exploitation rates for brood years in the 1980's ranged from 60 percent to 82 percent, but ranged from 34 percent to 49 percent for brood years 1992 to 1994. As noted above, spawning escapement has exceeded the goals, partially in response to declining harvest.

Table 2. Total fishery-related, adult equivalent exploitation rates of Green River summer/fall chinook for brood years 1978 – 1994 (CTC analyses cited in NMFS 2000)

'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94
.89	.89	.93	.84	.72	.62	.71	62	.78	.76	.82	.74	.64	.53	.34	.37	.49

Green River chinook are caught by fisheries in British Columbia, in past years primarily in Georgia Strait and the west coast of Vancouver Island. Mortality in British Columbia fisheries has declined in recent years. Currently, the majority of impacts occur in Washington recreational, net, and troll fisheries (CTC 1999, NMFS 2000). Recreational and net harvest in the terminal area comprises the majority (i.e.,54 percent in 2000) of Washington impacts.

Table 3. Harvest distribution of Green River fall chinook (CTC analysis cited in NMFS 2000).

Brood years	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	1%	25%	10%	37%
1991-94 avg	0%	13%	2%	28%

Management Objectives

The co-managers manage fisheries to meet or exceed the spawning escapement goal of 5,800 Green River chinook. In fact, the goal has been met or exceeded in 9 of the last 13 years. The co-managers expect that the goal will continue to be met or exceeded as a result of this management approach. The co-managers will also expect to further refine their management plan for Green River chinook over the next two years in light of on-going ESA recovery planning, to ensure harvest impacts are consistent with recovery of listed stocks. When the escapement is expected to be less than 5,800, the co-managers will discuss what additional actions, if any, may be appropriate to bring the escapement above the 5,800 level.

Management objectives for Green River chinook include an exploitation rate objective for pre-terminal fisheries and a procedure to manage terminal-area fisheries, based on an inseason abundance update (ISU), to assure that the escapement goal will be achieved. A low abundance threshold is identified to guard against abundance falling below the point of instability. This management regime assures that harvest of Green River chinook will not impede recovery of the ESU.

Pre-terminal fisheries in Washington are managed to achieve a 15 percent (‘SUS’) exploitation rate, as estimated by the FRAM model. Pre-terminal fisheries include the coastal troll and recreational fisheries managed under the Pacific Fisheries Management Council, and commercial net and recreational fisheries in Puget Sound outside of Elliott Bay.

Due to restriction of pre-terminal fisheries a greater proportion of allowable harvest will be available in the terminal fishery in Elliott Bay and the Duwamish River, where tribal net fisheries and recreational fisheries will be managed on the basis of the terminal area ISU.

The central objective of terminal-area fisheries management is to assure adequate natural spawning escapement and to supply broodstock to the fisheries enhancement program. There is no genetic distinction between hatchery and natural-origin adults, though concern has been expressed that hatchery-origin that spawn naturally are obscuring the low productivity of natural origin recruits, and reducing the fitness of natural spawners by interbreeding. However, the current productive capacity of the natural system is not well quantified, and the potential effects of interbreeding only theoretically described. The terminal area harvest regime has resulted in achievement of the nominal escapement goal since 1995.

Terminal fisheries are managed to achieve the escapement goal of 5,800. In-season assessment of the extreme terminal abundance, based on catch rates by a test fishery in Elliott Bay and/or commercial fisheries in the Duwamish River and Elliott Bay enables fishery managers to shape the terminal recreational and commercial fishery to achieve the escapement goal. The ISU has been successful in providing more accurate estimates of abundance, but it relies on the pre-season forecast of the proportion of natural-origin chinook in the terminal run. An evaluation of its performance in 1992 – 1994 indicates that the ISU estimates of abundance were closer to the true abundance in all three years, and guided management decisions correctly in either constraining or liberalizing terminal harvest direction (PSSSRG 1997). However, deviations between the forecasted natural component and their true abundance were substantial, and these, in combination with a relatively unrestricted sport fishery contributed to under escapement of natural spawners in 1993 and 1994. Accurate accounting of commercial and recreational harvest is essential to the ability of the managers to attain the escapement goal consistently. The co-managers have made steady progress toward improved accounting in recent years.

Pre-season forecasts have indicated that the natural return (i.e., terminal run) to the Green River would be greater than the hatchery return in two years (1995 and 1996) in the period since 1989. Post-season assessment of escapement has shown that the actual natural escapement exceeded the hatchery return twice (1991 and 1992) between 1989 and 1996. These estimates do not account for hatchery fish present in the naturally spawning population, nor natural origin fish entering the rack. As stray rates are better quantified with the return of mass-marked hatchery fish in coming years these estimates will also improve.

Review of the ISU model, prior to year 2000 fisheries, reached two significant conclusions. First, it was observed that catch from the first commercial openings in the bay and river were a better predictor than the three-week, five-boat test fishery in the bay (Bob Conrad, NWIFC, memo 2/10/00). Second, it was recommended that the managers avoid use of the ISU model output as a point estimate (B. Conrad, NWIFC pers comm).

Application of the ISU in 2000 was manifest in setting thresholds below which planned directed fisheries would not proceed. A value below 100 chinook for the test fishery would cause cancellation of the commercial and sport fisheries. A value below 1000 chinook for the first commercial opening would cause cancellation of any further fishing. These values corresponded with a total run of about 15,000 chinook, well above the low abundance threshold of 4,000 (assuming a 45:65 natural: hatchery ratio).

A low-abundance threshold of 1,800 natural spawners is established for the Green River management unit on the basis of the lowest observed escapement resulting in a higher escapement four years later. If natural escapement is projected to fall below this threshold during pre-season planning, then additional management measures will be implemented in accordance with procedures established in Appendix C, to minimize fishery-related mortality. The terminal fishery may also be shaped to increase escapement if the in-season update indicates that the threshold will not be attained.

Data gaps

Several aspects of the productivity of Green River chinook are potentially affected by hatchery-origin fish spawning naturally. The abundance, timing, spawning distribution, and age structure of natural-origin chinook may be masked by the presence of hatchery-origin fish. The viability of the natural origin population cannot be accurately assessed without determining the effects of hatchery straying, so the need for this information will prioritize research. Below are descriptions of the data needs and how they are being addressed.

Data need	Related project
Quantification of the proportion of natural escapement that is comprised of hatchery strays.	Completion of a CWT data set for refinement of current CWT-based estimates. (work in progress) Mass marking of hatchery production. (Brood year 1999 marked; 2000 proposed)
Re-evaluation of escapement estimation methodology	Expanded surveys to calibrate expansion of index area data to total. (begun in 1998 – work continues.) Mark/recapture study to independently calibrate total escapement estimate in association with expanded survey effort. (done in 2000 – proposed for two more years)
Estimation of the number of Chinook fry and smolts that emigrate annually from the mainstem Green, Newaukum and Soos Creeks.	Trap placement in the mainstem Green and Soos Creek (completed in 1999-proposed to continue)
Estimation of differential survival of natural and hatchery origin Chinook in-situ in the Green.	A literature review of methodologies that may have utility for an in-situ experiment should be done.
Estimation of estuarine hooking mortality if selective fisheries are proposed for Elliott Bay.	A literature review and preliminary study design should be done.

13.7 White River Management Unit Status Profile

Component Stocks

White River spring

Geographic description

White River spring chinook spawn in the lower mainstem, below the Puget Power diversion dam at RM 23.4, though habitat suitability is constrained by the flow regime. Adult fish are trapped at the diversion dam and transported into the upper watershed, above Mud Mountain Dam, where they spawn in the West Fork of the White River, Clearwater River, Greenwater River, and Huckleberry Creek. The White River population is the only spring stock still present in southern Puget Sound, is geographically isolated from summer/fall stocks, and genetically distinct from all other chinook stocks in Puget Sound. Production is supplemented by the White River hatchery program, and the stock has, in past years, been maintained as captive brood at the Hupp Springs and Peale Pass net pen facilities. The supplementation program is considered essential to recovery, so hatchery production is included in the listed ESU.

Life History Traits

Spring chinook enter the Puyallup River from May through mid-September, and spawn from mid-September through October. Fish arriving at the Buckley trap after August 15th are not used for broodstock, to avoid the potential for mixing with fall chinook.

Fry emerge from the gravel in late winter and early spring. In contrast to other spring stocks in Puget Sound, White River chinook smolt emigrate primarily (80 percent) as subyearlings (SSSCTC 1996), after a short rearing period of three to eight weeks. Adults mature primarily at age-3 or age-4.

Status

Escapement of White River chinook exceeded 5,000 in the early 1940's, but the construction of hydroelectric and flood control dams, and degradation of the spawning and rearing habitat reduced abundance to critical levels in the 1970's. Escapement was less than 100 through the 1980's and fell below 10 in 1984 and 1986. A supplementation program has been operating since 1971, and it has succeeded in raising escapement to levels between 300 and 600 in recent years (Table 1). The geometric mean of escapement in 1992 – 1996 was 477, and for the three more recent years, 413.

Table 1. Spawning escapement of White River spring chinook, 1990-1999. Upper river figure represents untagged fish captured at the Buckley trap and transported to upstream spawning grounds (ACOE data cited in HGMP). Broodstock includes collections at Minter Creek, South Sound Netpens, and White River hatchery, and excludes jacks (WDFW et al 1996 cited in HGMP).

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Upper river	275	194	406	409	392	605	630	400	316
Broodstock		1206	1606	1444	2033	1982	924	822	442
Total		1400	2012	1853	2425	2587	1554	1222	758

The status of White River spring chinook is critical, as evidenced by recent spawning escapement falling chronically below the nominal goal of 1,000 natural spawners. Degraded spawning and rearing habitat, and the migration blockage imposed by dams, currently imposes severe constraints on natural productivity. The contribution of natural-origin adults to spawning escapement has not been quantified, but there is evidence to suggest that the stock is not currently viable in the absence of supplementation. The supplementation program has succeeded in raising escapement above the critically low levels seen in the 1970's and 1980's, and it may continue to protect the viability of the stock, but natural production will not recover until the habitat constraints are addressed.

Harvest distribution and exploitation rate trends:

Essentially all of the harvest mortality of White River springs occurs in Puget Sound, their migration timing through coastal fisheries in British Columbia and Washington apparently precluding harvest in these outside fisheries under recent management regimes. For the period of 1991 – 1996, an average of three percent of total mortality occurred in Georgia Strait. Fisheries mortality in Washington occurred primarily in recreational fisheries (86 percent) and net fisheries in Puget Sound. Prior to 1994, mortality also occurred in Washington troll fisheries (CTC 1999). An analysis including more recent tag data indicates that mortality outside of Puget Sound has been reduced to 1% (Table 2).

Table 2. The distribution of adult equivalent exploitation rates for White River spring chinook (unpublished CTC analysis cited in NMFS 2000).

Brood years	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	0	.04	.03	.61
1991-94 avg	0	.01	0	.48

Increasingly conservative management of Washington fisheries has resulted in the total exploitation falling from greater than 70 percent in the early 1980's broods, to below 50 percent since brood year 1992. The total exploitation rate projected by the FRAM model for the 2000
management year was 16 percent. The fisheries simulation model (FRAM) has been modified to incorporate only White River fingerling tag codes, which show a slightly different harvest distribution than yearlings that formerly comprised the PSC Indicator Stock.

Table 3. Total fishery-related, adult equivalent exploitation rates of White River spring chinook for brood years 1979 – 1994 (CTC analyses cited in NMFS 2000).

	AEQ ER			AEQ ER
1979	0.91		1987	0.68
1980	0.77		1988	0.63
1981	0.51		1989	0.63
1982	0.74		1990	0.74
1983	0.78		1991	0.55
1984	0.71		1992	0.50
1985	0.70		1993	0.46
1986	0.75		1994	0.45

Management Objectives

Fisheries in Washington will be managed to achieve a total exploitation rate, including fisheries in British Columbia, no greater than 17 percent, as measured by the FRAM simulation model. Achievement of this rate requires severe constraint of Puget Sound net and recreational fisheries, and allows only a minimal tribal ceremonial fishery in the river. Tag recovery and escapement data are insufficient, at present, to support direct assessment of the productivity of the stock.

The current management objective constrains fishing mortality severely to provide sufficient spawning escapement to maintain the viability of the stock by assuring that natural escapement exceeds the critical threshold of 200. Escapement below this level is believed to present significant risk to genetic diversity and exposure to depensatory mortality factors, particularly when considering the low productivity of naturally spawning fish.

If preseason fishery simulation modeling suggests that escapement will not exceed the low abundance threshold, further conservation measures will be implemented in fisheries that catch White River chinook, so as to reduce their total exploitation rate to a level that is defined by modeling the fishing regime described in Appendix C. A very conservative approach is warranted in managing this stock, and projected escapement near the critical threshold, or failure to achieve broodstock collection objectives, will be considered grounds to re-institute the captive brood program.

Data gaps

- Description of spawning distribution in the upper White River system.
- Quantification of hatchery- and natural-origin adults on the spawning grounds.
- Estimation of natural smolt production.
- Estimation of pre-spawning mortality of adults that are trapped and transported above Mud Mountain dam.

13.8 Puyallup Management Unit Status Profile

Component Stocks

Puyallup River fall chinook
South Prairie Creek fall chinook

Geographic description

Fall chinook spawn primarily in South Prairie Creek (a tributary of the Carbon River) up to RM 15, the Puyallup mainstem up to Electron Dam at RM 41.7, the lower Carbon River, Voights's Creek and Kapowsin Creek, and possibly the lower White River. Juvenile chinook produced at the Puyallup Hatchery are outplanted to acclimation ponds in the upper Puyallup River, above the dam. Construction of a fishway at Electron Dam is expected to re-establish access to the upper river in the near future.

Life History Traits

Hatchery programs have introduced non-native stocks, primarily of Green River origin, into the Puyallup system, so it is not clear that naturally spawning chinook bear the native genetic legacy. A remnant native stock may persist in South Prairie Creek, though genetic testing to date has not been conclusive in that respect.

Freshwater entry into the Puyallup River begins in late July, and spawning occurs from mid-September through mid-November. Based on scale samples collected in 1992-93, returning adults were primarily (76 percent) age-4, and age-3 and age-5 fish made up 16 and 6 percent of the sample (WDF et al 1993 cited in Myers et al 1998). Juveniles exhibit ocean-type life history, primarily, with estimated 97 percent of smolts emigrating as subyearlings (WDF et al 1993 cited in Myers et al 1998).

Status

Natural spawning escapement of Puyallup fall chinook has ranged from 1,550 to 5,000 over the last ten years, with averages for the last three years, and the preceding five years, stable at about 2,500. Median escapement to South Prairie Creek was 25 for the period 1972 – 1991, and ranged from three to 95. The turbid nature of the Puyallup River, due to its glacial origin, makes enumeration of spawners or redds difficult in the mainstem, so the accuracy of the following system-wide estimates is uncertain.

Table 1. Spawning escapement of Puyallup River fall chinook, 1990-1999.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3,515	1,702	3,034	1,999	2,526	2,701	2,440	1,550	4,995	1,986

The former nominal escapement goal, that was intended principally to assure adequate broodstock to hatchery programs, was 3,250.

Harvest distribution and exploitation rate trends:

The harvest distribution of Puyallup fall chinook has not been directly assessed, due to inconsistent tagging of hatchery releases, but they are presumed to have as similar distribution to Nisqually fall chinook, because of similar genetic characteristics and life history. In recent years, most of the harvest mortality occurred in Puget Sound fisheries, but they are also caught in British Columbia and on the Washington coast. The Puget Sound exploitation rate has declined slightly for brood years 1991-94 in comparison with the preceding 14 brood years.

Table 2. Distribution of fishing exploitation for Nisqually fall chinook (CTC analysis cited in NMFS 2000).

Brood years	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	0	.21	.12	.50
1991-94 avg	0	.10	.02	.58

The annual exploitation rate was consistently between 60 and 70 percent for management years 1986 to 1996, based on post-season estimates made by the FRAM model.

Table 3. Total fishery-related, adult equivalent exploitation rates of Puyallup River fall chinook for management years 1983 – 1996 (unpublished FRAM validation runs).

83	84	85	86	87	88	89	90	91	92	93	94	95	96
.76	.66	.73	.68	.79	.71	.66	.66	.65	.64	.65	.71	74	.62

The total exploitation rate for Puyallup falls projected by the FRAM model for 1999 and 2000 were 51 and 38 percent, respectively.

Management Objectives

Since the existence of an indigenous fall chinook stock in the Puyallup system is uncertain, and current natural production is substantially augmented by hatchery-origin fish, the harvest management objectives will reflect the need to adequately seed natural spawning areas until the productive capacity of habitat is quantified, and the existence of an indigenous stock is resolved. Until recently the system was managed to supply adequate broodstock to the hatchery programs.

The harvest management objective for Puyallup fall chinook is to not exceed a total exploitation rate of 50 percent, to assure that a viable, natural-spawning population is perpetuated. Natural spawning escapement of 500 chinook in South Prairie Creek will be the index of adequate natural spawning, because escapement is more accurately estimated in that tributary. Pre-terminal and terminal fisheries were constrained in 1999 and 2000 to achieve this objective. The productive capacity of habitat in South Prairie Creek, or in the Puyallup mainstem and tributaries is not quantified, so a system-wide escapement goal has not been established. By reducing the total exploitation rate, relative to those levels in the early- to mid- 1990's, this harvest regime will provide a significantly greater level of natural escapement. Achieving higher natural escapement, under the new management objective, will experimentally probe the productivity of natural spawners in the system.

A low abundance threshold of 500 is established for the Puyallup fall management unit. If escapement is projected to fall below this threshold, fisheries-related mortality will be reduced to a level defined by the fisheries regime described in Appendix C. The threshold is set above the point of stock instability, to prevent escapement from falling to that level which incurs substantial risk to genetic integrity, or expose the stocks to depensatory mortality factors.

Data gaps

- Improve spawning escapement estimates for the Puyallup River and/or validate the use of South Prairie Creek and Wilkeson Creek counts as an index for the system.

- Estimate the contribution of hatchery- and natural-origin adults to natural spawning , by mass-marking hatchery production. Brood year 1999 hatchery production was 100% marked.

- Develop a spawner / recruit function for natural-origin, naturally spawning chinook to validate the recovery exploitation rate objective. This task dependent on completion of previous two tasks.

13.9 Nisqually River Management Unit Status Profile

Component Stocks

Nisqually fall

Geographic description

Adult chinook ascend the mainstem of the Nisqually River to river mile 40, where further access is blocked by the La Grande and Alder dams, facilities that were constructed for hydroelectric power generation by the City of Tacoma's public utility. It is unlikely that chinook utilized higher reaches in the system, prior to the dams' construction. Below La Grande dam the river flows to the northwest across a broad and flat valley floor, characterized by mixed coniferous and deciduous forest and cleared agricultural land. Between river miles 5.5 and 11 the river runs through the Nisqually Indian Reservation, and between river miles 11 and 19 through largely undeveloped Fort Lewis military reservation. At river mile 26, a portion of the flow is diverted into the Yelm Power Canal, which carries the water 14 miles downstream to a powerhouse, where the flow returns to the mainstem at river mile 12. A fish ladder provides passage over the diversion. Both Tacoma's and Centralia's FERC license requires minimum flows below the project.

Fall chinook spawn in the mainstem above river mile 3, in numerous side channels, as well as in the lower reaches of Yelm Creek, Ohop Creek, the Mashel River and several smaller tributaries. Production is augmented by production at the Kalama Creek and Clear Creek hatcheries, which are operated by the Nisqually Tribe. Supplementation of spawning in the upper mainstem, by outplanting of juvenile chinook into suitable rearing habitat, is an important objective of the hatchery program.

Life History Traits

Adult fall chinook enter the Nisqually River system from July through September, and spawning activity continues through November. After emerging from the gravel, juveniles typically spend two to six months in freshwater before beginning their seaward migration. Residence time in their natal streams may be quite short, as the fry usually move downstream into higher order tributaries or the mainstem to rear. Extended freshwater rearing for a year or more, that typifies some Puget Sound summer/fall chinook stocks, has not been observed in the Nisqually system.

Returning adults mature primarily at age-3 and age-4, comprising 45 and 31 percent, respectively (WDF et al 1993, WDFW 1995 cited in Myers et al 1998).

Stock Status

It is generally agreed that native spring and fall chinook stocks have been extirpated from the Nisqually River system, primarily as a result of blocked passage at the Centralia diversion, de-watering of mainstem spawning areas by hydroelectric operations, a toxic copper ore spill associated with a railroad trestle failure, and other habitat degradation (Barr, 1999). Studies are underway to determine whether any genetic evidence suggests persistence of the native stock. Initial results indicate that the existing naturally-spawning and hatchery stocks are identical, and were derived from hatchery production that utilized, principally, Puyallup River and Green River fall chinook. Like other stocks in South Puget Sound, in which current production is based on naturalized and supplemented returns from a hatchery program, the Nisqually has been managed to achieve escapement sufficient to provide broodstock to the enhancement program.

Natural escapement has not met the escapement goal of 900 since 1994. (The escapement goal was increased to 1,100 effective 2000.) Recent natural spawning escapement has ranged from 100 to 1,700 (Table 2), and hatchery returns have ranged from 200 to 4,100, in the period between 1991 and 1998. Escapement surveys are made difficult in the mainstem by the turbidity caused by glacial flour.

Table 1. The abundance of fall chinook returning to the Nisqually River system.

	Peak escapement counts		Natural escape [3]	Hatchery escape.	Terminal harvest	Terminal Run
	Mainstem redds[1]	Mashel R. live+dead [2]				
1991	54	5	953	201	428	1582
1992	1	13	106	311	301	718
1993	94	8	1655	1372	4163	7190
1994	98	9	1730	2104	6123	9957
1995	40	20	817	3623	7171	11611
1996	26	12	606	2701	5365	8672
1997	13	12	340	3251	4309	7900
1998	25	60	834	4067	7990	12891
1999			1399			

[1] Mainstem redd counts, from R.M. 21.8 to 26.2, are multiplied by 2.5 to estimate number of spawners.
[2] Mashel fish counts, from R.M. 0.0 to 3.2 expanded by visibility factor some years.
[3] Peak count of spawners in the mainstem and Mashel River index areas is expanded by 6.81 to estimate.

Harvest distribution and exploitation rate trends:The harvest distribution of Nisqually chinook has been described from recoveries of coded-wire tagged fingerlings released from the Kalama Creek hatchery. In recent years 14 percent of the total harvest mortality has occurred in British Columbia, primarily in Georgia Strait, but also in northcentral B.C., the west coast of Vancouver Island, and other Canadian net and sport fisheries. Approximately equal harvest has occurred in sport and net fisheries in Puget Sound, with fewer mortalities occurring in Washington troll fisheries.

Table 2. Harvest distribution of Nisqually River fall chinook (CTC analysis cited in NMFS 2000).

Brood years	Alaska	B.C.	PFMC	Puget Sound
1977-90 avg	0	.21	.12	.50
1991-94 avg	0	.10	.02	.58

The total exploitation rate has declined substantially from levels exceeding 90 percent in the early 1980's, to an average of 70 percent for brood years 1990 – 1994. The high exploitation in past years was considered appropriate for hatchery stock. For the last two years the total exploitation rate projected pre-season by the FRAM model was 74 percent.

Table 3. Total fishery-related, adult equivalent exploitation rates of Nisqually River fall chinook for brood years 1977 – 1994 (CTC analyses cited in NMFS 2000).

1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
.98	.99	.97	.86	.92	.96	.83	.91	.87	.82	.84	.73	.57	.73	.66	.82

Management Objectives

Because the Nisqually management unit is not a unique, native stock, the need to optimize natural production from natural-origin spawners will be balanced against the fishery enhancement objectives of the hatchery programs. In this sense, the Nisqually unit is similar to other South Puget Sound and Hood Canal natural units in which the production depends on non-native, introduced chinook stocks, and where natural productivity is severely constrained by habitat degradation. For these units, management intent is significantly distinct from other Puget Sound management units in which production is comprised primarily of native, naturally-spawning stocks.

The productivity and capacity of the habitat in the Nisqually system have been assessed to be 6.4 recruits per spawner and 2300 spawners, respectively. Analysis is proceeding to confirm these numbers and to determine the appropriate natural escapement goal (Barr, 1999

A recovery exploitation rate has not been developed for the Nisqually chinook stock. The terminal fishery is managed based on an inseason updated runsize estimated by linear regression against catch per unit effort during the first two weeks of the river fishery. This inseason assessment of natural run strength will enable the fishery to be managed for the 1,100 escapement goal. When the in-season update indicates that the escapement goal (1,100) will not be achieved, terminal area fisheries will be constrained by agreement between the co-managers with the objective of increasing spawner abundance to a level at or above the escapement goal.

It is expected that further productivity analysis, enabled by better quantification of natural escapement, and assessment of the contribution of natural-origin adults to that escapement, will allow development of a recovery exploitation rate objective that reflects the recent productivity of the stock. However, in-season assessment will continue to be used to estimate the terminal abundance, and the tribal net fishery in the river will continue to be managed to achieve the natural the escapement goal of 1,100 for 2001 and 2002, and a minimum of 500 natural-origin recruits in 2003, in order to optimize economic and subsistence benefits that comprise the treaty right.

Data gaps

- Improve total natural escapement estimates, including age-specific estimates of both natural and hatchery-origin recruits and develop stock-recruit analysis.
- Test the accuracy of the in-season assessment of extreme terminal abundance, and improve the in-season update model as new data allows.
- Quantify the current natural productivity of the system.

13.10 Skokomish River Management Unit Status Profile

Component Stocks

Skokomish summer/fall

Geographic description

Spawning takes place in the mainstem Skokomish River up to the confluence with the South and North forks, in the South Fork of the Skokomish River, primarily below RM 5.0, and in the North Fork up to RM 17, where Cushman Dam blocks higher access. Most spawning in the North Fork occurs below RM 13, because flow fluctuation associated with operations of the hydroelectric facility limit access and spawning success higher in the system (WDF et al. 1993).

On the North Fork Skokomish, two hydroelectric dams block passage to the upper watershed. However, a small, self-sustaining population of landlocked chinook salmon is present in Lake Cushman, upstream of the dams. Adults spawn upstream of the lake in the North Fork Skokomish River from river mile 28.2 to 29.9 during November.

Life History Traits

Genetic characterization of the Skokomish chinook stocks has, to date, been limited to comparison of adults and juveniles collected from the Skokomish River with adults from other Hood Canal and Puget Sound populations. Genetic collections were made during 1998 and 1999 in the Skokomish River and there appeared to be no significant genetic differentiation between natural spawners and the local hatchery populations. It appears that Hood Canal area populations may have formed a group differentiated from south Puget Sound populations, possibly indicating that some level of adaptation may be occurring following the cessation of transfers from south Sound hatcheries (Anne Marshall, WDFW memo dated May 31, 2000). Current adult returns are a composite of natural- and hatchery-origin fish. During 1998 and 1999, known hatchery-origin fish comprised from 13% to 41% of the samples collected on the natural spawning grounds. Genetic analysis of samples collected from Lake Cushman was inconclusive as to stock origin, and exhibits low genetic variability. (Marshall, 1995a).

Summer/fall chinook enter the Skokomish River starting in late July with the majority of the run entering from mid-August to mid-September. Chinook in the Skokomish River spawn from mid-September through October with peak spawning during mid-October. Adults mature primarily at age-3 (33 percent) and age-4 (43 percent); the incidence of age 2 fish (jacks) is highly variable. During 1999, based on a sample of 143 fish, the age composition of naturally-spawning chinook in the Skokomish River system was estimated to be 2.8% age 2, 58.0% age 3, 38.5% age 4, and 0.7% age 5 fish (Thom H. Johnson, WDFW memo dated November 8, 2000). Consistent with most other summer/fall populations in Puget Sound, naturally produced smolts emigrate primarily during their first year; 2 percent of the smolts are yearlings (Williams et al 1975 cited in Myers et al 1998). Most naturally-produced chinook juveniles in the Skokomish River outmigrate during the spring and early summer of their first year of life as fingerlings (Lestelle and Weller 1994).

Status

SASSI classified Hood Canal summer/fall chinook as a single stock of mixed origin (both native and non-native) with composite production (sustained by wild and artificial production) (Washington Dept of Fisheries et al. 1992). The combination of recent low abundances (in all tributaries except the Skokomish River) and widespread use of hatchery stocks (primarily originating from sources outside Hood Canal) led to the conclusion in SASSI that there were no remaining genetically unique, indigenous populations of chinook in Hood Canal. However, a sampling effort is currently under way (led by WDFW in cooperation with NMFS and Treaty Tribes) to collect genetic information from chinook juveniles and adults in the tributaries of Hood Canal. This investigation is intended to provide further information on the genetic source and status of existing chinook populations.

The existence of historical, indigenous populations that have not been significantly impacted by past management practices and that remain sustainable is at least questionable. The genetic sampling effort referenced above is intended to help resolve remaining uncertainty about the existence of any historical, indigenous populations. In the interim, management measures must be formulated to provide reasonable protection for natural chinook and adequate flexibility for future change**.**

Historically, the Skokomish River supported the largest natural chinook production of any stream in Hood Canal. However, habitat degradation has severely reduced the productive capacity of the mainstem and South Fork portions of the system. As previously noted, the North Fork has been blocked by two hydroelectric dams. Hatchery chinook production has been developed at Washington State's George Adams and McKernan hatcheries to augment harvest opportunities and to provide partial mitigation for reduced natural production in the Skokomish system, primarily caused by the North Fork dams. The Skokomish Tribe, whose reservation is located near the mouth of the river, has a reserved treaty right to harvest chinook salmon.

Over the period from 1995 – 2000, natural spawning escapement ranged from 450 to 1,800, exceeding the nominal goal of 1,650 twice (Table 1)

Table 1. Total spawning escapement of Skokomish River fall chinook, 1990 - 2000.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hatchery	2186	3068	294	612	495	5196	3100	1885	5584	8227	4033
Natural	642	1719	825	960	657	1398	995	452	1627	1817	843
Total	2828	4787	1119	1572	1152	6594	4095	2337	6911	10044	4876

Harvest distribution and exploitation rate trends:

The harvest distribution of Skokomish chinook has been described from recoveries of coded-wire tagged fingerlings released from the George Adams hatchery. In recent years, fisheries in British Columbia (Georgia Strait, north-central B.C., the west coast of Vancouver Island, and other Canadian net and sport fisheries), accounted for about 15% of the total fishing mortality of Skokomish chinook (Table 2). Total mortality in Canadian fisheries has declined substantially, particularly due to the increasing restrictions on the west coast of Vancouver Island fisheries. For catch years 1991 – 1996, about 35 percent of the total fishing mortality occurred in sport fisheries in Washington, 18 percent in Puget Sound net fisheries, and 10 percent in troll fisheries. The proportion of harvest occurring in coastal troll and sport fisheries has declined from an average of 14 percent of the total fishing mortality in brood years 1977 – 1990, to an average of 3 percent in brood years 1991 – 1994.

Table 2. Total exploitation and harvest distribution of Skokomish River summer/fall chinook (CTC analysis cited in NMFS 2000).

Brood Years	Total ER	Alaska	B.C.	PFMC	Puget Sound	Other
1977-90 avg	.87	0	29.9%	16.1%	54%	0
1991-94 avg	.42	2.4%	35.7%	7.1%	57.1%	0

The total brood exploitation rate, computed from CWT recoveries, has declined substantially from levels exceeding 90 percent in the early 1980's, to an average of 42 percent for brood years 1991 – 1994 (Table 3). The total exploitation rates projected pre-season by the FRAM model for management years 1999 and 2000 were 21 and 48 percent, respectively. FRAM estimates of annual (i.e. management year) total exploitation rates from 1990 – 1996 range from 30 to 76 percent, and average 44 percent.

Table 3. Total fishery-related, spawner equivalent exploitation rates of Skokomish River summer/fall chinook for brood years 1977 – 1994 (CTC analyses cited in NMFS 2000).

Brood Years																
78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
.82	.95	.91	.85	Na			.91	.93	.87	.93	.86	.69	.51	.46	.48	.22

Management Objectives

The immediate and short-term objective for Skokomish River is to manage chinook salmon as a composite population (including naturally and artificially produced chinook). The composite population will be managed, in part, to achieve a suitable level of natural escapement; and to continue hatchery mitigation of the effects of habitat loss; and to provide to the Skokomish Tribe partial mitigation for its lost treaty fishing opportunity. Habitat recovery and protection measures will be sought to improve natural production. Over time, alternative management strategies will be explored that may lead to improved sustainable natural production, and reduced reliance on mitigative hatchery support for the Skokomish stock and fisheries.

The nominal escapement goal for the Skokomish River is 3,150. It is the sum of spawner requirements for 1,650 in-stream spawners (HCSMP; 1985) and 1,500 spawners required for the maintenance of on-station hatchery production (see 1996 Production Evaluation MOU, PNPTC-WDFW-USFWS). Recent composite escapement has been substantially more than 3,150 fish, level, averaging 5,635 for the 1996 – 2000 period, and exceeding the 3,150 goal in four of the last five years. In the same period, natural escapement has averaged 1,147 and approached or exceeded 1,650 in two of the five years. Escapements to the hatchery have averaged 4,566 fish and have exceeded the 1,500 fish goal in all five years. (Table 1).

The escapement goal of 3,150, along with its component requirements for natural and hatchery spawners, (WDF Tech. Rept. 29, 1977; PSSMP, 1985; HCSMP, 1985; HCSMP Prod MOU, 1996) is intended to maintain full hatchery mitigation and meet current estimates of MSY escapement to natural spawning areas (under current habitat conditions).

A low abundance threshold escapement of 1,300, represents the aggregate of 800 natural spawners and 500 adults returning to the hatchery rack. At these levels, the hatchery escapement component represents the minimum requirement to maintain production. The natural escapement component threshold is set at approximately 50% of the current MSY estimate and represents a level necessary to ensure in-system diversity and spatial distribution. In the 1996 – 2000 period, the low threshold was exceeded in all years for this management unit. Component low thresholds in these years were exceeded in all years for hatchery escapement, and in four of the five years for natural escapement.

During the recovery period, pre-terminal fisheries in southern U.S. areas (SUS), will be managed to ensure a total rate of exploitation of 15%, or less, as estimated by the FRAM model (est. of 1997-1999 SUS preseason impacts). Pre-terminal fisheries include the coastal troll and recreational fisheries managed under the Pacific Fisheries Management Council, and commercial and recreational fisheries in Puget Sound, outside Hood Canal. Terminal fisheries are managed to achieve the escapement goal of 3,150. If the recruit abundance is insufficient for the goal to be met, OR regardless of the total escapement, the naturally spawning component of this population is expected to fall below 1,200 spawners, OR the hatchery component is expected to result in less than 1,000 spawners, additional terminal fishery management measures will be considered, including the following:

- Commercial and recreational fisheries in northern Hood Canal areas (WDFW Areas 12 and 12B) will be reduced or eliminated in the months of July through September.
- Commercial and recreational fisheries in southern Hood Canal areas (WDFW Areas 12C and 12D) will be “shaped” to direct the majority of the fishing effort to the Hoodsport Hatchery zone, thus greatly reducing impacts to the Skokomish Management Unit. In 2000, approximately 90% of the total commercial harvest in Area 12C was directed at, and taken, in that zone.

- In the Skokomish River, Treaty Indian commercial fisheries will be limited in August and September, to areas upstream of the Skokomish delta milling area (upstream of the SR 106 crossing), and downstream of the U.S. 101 crossing.
- In the Skokomish River, recreational salmon fisheries will be limited, through September, to areas upstream of the mouth and downstream of the U.S. 101 crossing.

If, despite the implementation of the above measures, the projected escapement is less than 1,300 total spawners, OR regardless of the total escapement, the naturally spawning component of this population is expected to fall below the low threshold of 800 spawners, OR the hatchery component is expected to result in less than 500 spawners, pre-terminal SUS fisheries will be constrained to minimize mortality, in accordance with conservation measures described in Appendix C. In Hood Canal terminal areas the co-managers will consider and implement additional actions as necessary, including fishery closures, in order to increase the escapement to a level closer to, or above, the low thresholds.

All of the measures shall initially be based on preseason forecasted abundance and escapement projections and may be adjusted during the season, following inseason reassessment of the terminal abundance.

This management regime recognizes the need to optimize natural production in the Skokomish River. However, production potential is currently severely constrained by reduced habitat capacity and quality in the South Fork, and by the influence of the hydroelectric and re-regulation dams on the North Fork. The current productive capacity of habitat has not been quantified in terms of the number of adults required to fully seed the available spawning area or optimize smolt yield.

Principles that underlie the current management intent for Skokomish River chinook include:

- Full recovery of natural productivity in the Skokomish River cannot occur under the current hydroelectric operating regime and degraded habitat status;

- The management regime will provide adequate seeding of existing habitat and ensure the maintenance of in-system diversity and spatial distribution by assuring that (if available) at least 800, and up to 1,650 (the currently estimated level of MSY), natural spawners reach the spawning grounds;

- Natural production is dependent on the mitigative hatchery program to partly support natural escapement;

- Hatchery- and natural-origin spawners appear to be genetically similar, and have demonstrated their capacity to adapt to the Skokomish River environment.

- Access to harvest opportunity on returning adults produced by the enhancement program at George Adams Hatchery is mandated as partial mitigation for the effects of operation of the City of Tacoma's hydroelectric facility.

- The recovery objective for the ESU, which includes conservation and rebuilding of natural production that is representative of the geographic and genetic diversity that characterizes the ESU, is served, in part, by assuring that natural production of locally-adapted populations is recovered in the mid-Hood Canal streams (Duckabush River, Dosewallips River, and Hamma Hamma River) where habitat quality does not constrain to the extent that it does in the Skokomish River.

Management objectives for the Skokomish River management unit will evolve in response to improved understanding of natural productivity, and success in restoring the productive potential of habitat in the system.

Data gaps

- Improve escapement estimates for the South and North Forks of the Skokomish River.
- Test the accuracy of the in-season assessment of terminal abundance
- Develop means to assess the proportion of natural origin adults that are present in each escapement group (hatchery and natural)
- Quantify the current natural productivity of the system, under current escapement goals, in terms of recruits per spawners.

13.11 Mid-Hood Canal Management Unit Status Profile

Component Stocks

Hamma Hamma River summer/fall
Dosewallips River summer/fall
Duckabush River summer/fall

Geographic description

Chinook spawn in the Hamma Hamma River mainstem up to RM 2.5, where a barrier falls prevents higher access. Spawning can occur also in John Creek when flow permits access. A series of falls and cascades, which may be passable in some years, block access to the upper Duckabush River at RM 7, and to the upper Dosewallips River at RM 14. Spawning may also occur in Rocky Brook Creek, a tributary to the Dosewallips. Most tributaries to these three rivers are inaccessible, high gradient streams, so the mainstem provides nearly the entire production potential.

Life History Traits

Genetic characterization of the mid-Hood Canal stocks has, to date, been limited to comparison of adults returning to the Hamma Hamma River in 1999 with other Hood Canal and Puget Sound populations. These studies, although not conclusive, suggest that Hamma Hamma returns are not genetically distinct from the Skokomish River returns, or recent George Adams and Hoodsport hatchery broodstock (A. Marshall, WDFW unpublished data). The reasons for this similarity are unclear, but straying of chinook that originate from streams further south in Hood Canal, and hatchery stocking, could be contributing causes.

Status

The Mid-Hood Canal MU is comprised of chinook populations of the Dosewallips, Duckabush and Hamma Hamma watersheds. These populations are at low abundance (Table 1).

Current chinook spawner surveys are typically limited to the lower reaches of each stream. In the Hamma Hamma, the majority of the chinook spawning habitat is currently being surveyed. In the Dosewallips and Duckabush, however, the areas surveyed are transit areas and do not include all spawning areas; upper reaches have been occasionally surveyed since 1998. Therefore, for these latter rivers, escapement estimates are considered to be minimums. Prior to 1986 no reliable estimates are available because all escapement estimates for these rivers were made by extrapolation from the Skokomish River.

Table 1. Natural spawning escapement of Mid-Hood Canal fall chinook salmon, 1990-2000.

Stock	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
HammaHamma	35	30	52	28	78	25	11	0	172	557	381
Duckabush	10	14	3	17	9	2	13	6	57	151	28
Dosewallips	0	42	41	67	297	76	0	0	58	165	29
Total	45	86	96	142	384	103	24	6	287	873	438

SASSI classified Hood Canal summer/fall chinook as a single stock of mixed origin (both native and non-native) with composite production (sustained by wild and artificial production) (Washington Dept of Fisheries et al. 1992). The combination of recent low abundances (in all tributaries except the Skokomish River) and widespread use of hatchery stocks (primarily originating from sources outside Hood Canal) led to the conclusion in SASSI that there were no remaining genetically unique, indigenous populations of chinook in Hood Canal. A study is currently under way to characterize the genetic of chinook juveniles and adults in the tributaries of Hood Canal.

The status of the mid-Hood Canal chinook populations was not individually assessed in the SASSI document (WDF et al 1993), rather the Hood Canal natural and hatchery stocks were aggregated into a single unit for which status was assessed to be healthy. It has been assumed that many of the naturally-spawning chinook in the Hamma Hamma, Dosewallips, and Duckabush rivers have, in recent years, been due to straying of hatchery spawners, as well as adult returns from hatchery fry released into these rivers.

Harvest distribution and exploitation rate trends:

The harvest distribution of mid-Hood Canal chinook, and recent fishery exploitation rates, cannot be directly assessed because none of the component stocks have been coded-wire tagged. However, it is reasonable to assume, given their similar life history, that tagged fingerling chinook released from the George Adams Hatchery on the Skokomish River, follow a similar migration pathway and experience mortality in a similar set of pre-terminal fisheries in British Columbia and Washington.

Management of the terminal are fisheries in Hood Canal enables some separation of harvest between Skokomish/ Hoodsport and mid-Canal natural aggregate. With only Hoodsport and Skokomish tags available to model terminal impacts, the selective intent of the terminal regime will be estimated based on the freshwater entry period for mid-Canal rivers, and the distribution of historical net catch among the sub-areas of Hood Canal.

Estimates of the total exploitation rate for Skokomish hatchery chinook (Table 3) show a substantial decline beginning with brood year 1991. It is reasonable to conclude that mid-Canal stocks have experienced a similar decline, but their total exploitation rate has been lower, because the terminal area fishery, which can harvest a significant proportion of Skokomish chinook, has been restricted to the southern end of Hood Canal since the early 1990's.

Table 3. Total fishery-related, adult equivalent exploitation rates of Skokomish River summer/fall chinook salmon, for brood years 1977 – 1994 (CTC analyses cited in NMFS 2000).

Brood Year																
78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
.82	.95	.91	.85		Na		.91	.93	.87	.93	.86	.69	.51	.46	.48	.22

Management Objectives

The management objective, for the mid-Hood Canal Management Unit, is to maintain and restore sustainable, locally adapted, natural-origin chinook populations. Management efforts will focus on increasing natural population numbers and meeting specified minimum escapement rates or numbers. Fisheries are also being restricted to accommodate the escapement objective.

The existence of historical, indigenous populations that have not been significantly impacted by past management practices and that remain sustainable is at least questionable. The genetic sampling effort referenced above is intended to help resolve remaining uncertainty about the existence of any historical, indigenous populations. But in the interim, management measures must be forged that provide reasonable protection for natural chinook and adequate flexibility for future change.

During the recovery period, pre-terminal fisheries in southern U.S. areas (SUS), are managed to achieve a total rate of exploitation of 15%, or less, as estimated by the FRAM model (see Section IV). This pre-terminal exploitation rate is the same as that for the remainder of the Hood Canal management units because no means exist to separately assess the pre-terminal exploitation of this unit and there is no indication that its pre-terminal exploitation pattern is different between Hood Canal MUs. Pre-terminal fisheries include the coastal troll and recreational fisheries managed under the Pacific Fisheries Management Council, and commercial and recreational fisheries in Puget Sound, outside Hood Canal. Terminal areas for this management unit include the northern Hood Canal marine areas (WDFW Areas 12 and 12B) as well as the freshwater areas in each river.

The migration pathway and harvest distribution of mid-Hood Canal stocks is presumed to be similar to that of the Skokomish River indicator stock. The FRAM simulation model suggests that the terminal (Area 12C) and extreme-terminal (in-river) fisheries may harvest up to 25% of the Skokomish terminal run. However, terminal-area fisheries at the far southern end of Hood Canal, near the mouth of or in the Skokomish River, are not believed to harvest significant numbers of adults returning to the mid-Canal rivers of origin. Time and area restrictions are believed to be effective in relieving harvest pressure on the mid-Canal stocks.

When the escapement goal of 750 spawners (established as interim MSY in HCSMP) is not expected to be met, additional management measures will be considered for terminal area recreational and commercial fisheries, including season duration adjustments in marine areas, shaping of coho fisheries, and closure of recreational fisheries in the Dosewallips, Duckabush, and Hamma Hamma rivers. For example, terminal area harvest of the mid-Hood Canal management unit may be reduced by restricting commercial and recreational fisheries to the southern end of the Canal (Area 12C and the Skokomish River) during the passage of mid-Canal chinook, and/or shaping coho fisheries to occur only at the extreme end of the chinook freshwater entry period. Recreational fisheries can be similarly shaped to avoid directed take and minimize hooking mortality during fisheries directed at coho salmon. Additional restrictions may include elimination of freshwater fisheries in the Dosewallips, Duckabush and Hamma Hamma rivers during residency of adult spawners. These measures will be considered in order to ensure that the total SUS exploitation rate will not exceed 15%.

A low abundance threshold of 400 chinook spawners has been established for the Mid-Hood Canal management unit, which is approximately 50% of the current MSY goal for the Mid-Canal rivers, in the hood Canal Salmon Management Plan (1985). If escapement is projected to fall below this threshold, further conservation measures, which are described in Appendix C, will be implemented in pre-terminal and terminal fisheries to reduce mortality. The best available information indicates that escapement has been below the low abundance threshold in four out of the last five years. The co-managers recognize the need to provide across-the-board conservation measures in this circumstance, and to avoid an undue burden of conservation falling on the terminal fisheries.

The management intent is to maintain self-sustaining, locally adapted, populations. However, unless genetic studies conclude that unique stocks persist in individual mid-Hood Canal streams, the primary focus of management will be to ensure that sufficient spawners escape to these systems to maintain viable, self-sustaining populations. These populations will contribute geographic diversity to the ESU by their adaptation to the unique environmental conditions found in these drainages of the east slope of the Olympic Mountains.

Data gaps

- Improve escapement estimates
- Test the accuracy of the in-season assessment of extreme terminal abundance
- Develop means to assess the proportion of natural origin adults that are present in the escapement
- Quantify the current productivity and capacity of each system, under current escapement goals, in terms of recruits per spawners, as well as reassess spawner requirements.

13.12 Dungeness Management Unit Status Profile

Component Stocks

Dungeness River chinook

Distribution and Life History Characteristics

Chinook spawn in the Dungeness River up to RM 18.9, where a falls just above the mouth of Gold Creek blocks further access. Spawning has, in recent years, been concentrated between RM 3.3 and 10.8. Chinook also spawn in the Graywolf River up to RM 5.1.

The entry of mature chinook into the Dungeness River is not well described, but may occur from early summer through September. Spawning occurs from August through mid-October (WDF et al 1993). At the current low level of abundance distinct spring and summer populations are not distinguishable in the return. Chinook typically spawn two weeks earlier in the upper mainstem than in the lower mainstem (WDF et al 1993). Ocean- and stream-type life histories have been observed among juvenile chinook in the system, with extended freshwater rearing more typical of the early-timed segment (Ames et al 1975). Hirschi and Reed (1998) found that a relatively large number of chinook juveniles overwinter in the Dungeness River.

Smolts from the Dungeness River primarily exhibit an ocean-type life history, with age-0 outmigrants comprising 95 to 98 percent of the total (WDF et al 1993, Smith and Sele 1995, and WDFW 1995 cited in Myers et al 1998). Adults mature primarily at age four (63 percent), with age 3 and age 5 adults comprising 10 percent and 25 percent, respectively, of annual returns (PNPTC 1995 and WDFW 1995 cited in Myers et al 1998).

Stock Status

The SASSI report (WDF et al 1993) classified the Dungeness spring/summer as critical due to a chronically low spawning escapement to levels, such that the viability of the stock was in doubt and the risk of extinction was considered to be high.

The nominal escapement goal for the Dungeness River is 925 spawners, based on historical escapement that was observed in the 1970's and estimated production capacity re-assessed in the 1990's (Smith and Sele 1994). It has not been achieved in the past 10 years. Since 1996, the mean terminal abundance (i.e., terminal harvest and escapement) has been 127 (Table 1).

Chinook production in the Dungeness River is constrained, primarily, by degraded spawning and rearing habitat in the lower mainstem. Severe channel modification has contributed to substrate instability in spawning areas, and has reduced and isolated side channel rearing areas. Water withdrawals for irrigation during the migration and spawning season have limited access to suitable spawning areas.

The co-managers, in cooperation with federal agencies and private-sector conservation groups, have implemented a captive brood stock program to rehabilitate chinook runs in the Dungeness River. The primary goal of this program is to increase the number of fish spawning naturally in the river, while maintaining the genetic characteristics of the existing stock. The first returns of age-4 adults, from the brood year 1996 release of 1.8 million fingerlings, occurred in 2000. Uncertainty over the survival of these fingerlings has led managers to project abundance conservatively, (i.e., discount the potential return from supplementation).

In addition to the broodstock program, the local watershed council (Dungeness River Management Team) and a work group of state, tribal, county and federal biologists have been working on several habitat restoration efforts. Based on the 1997 report, "Recommended Restoration Projects for the Dungeness River" by the Dungeness River Restoration Work Group, local cooperators have implemented several engineered log jams, and acquired small refugia riparian properties. Other projects including larger scale riparian land acquisition, dike setback, bridge lengthening and estuary restoration are in the planning, analysis and proposal phases.

Management Objectives

The management objective for Dungeness chinook is to stabilize escapement and restore natural-origin recruit population basis through supplementation and fishery restrictions. Pre-terminal harvest in Washington waters will be constrained such that the southern U.S. exploitation rate does not exceed 10 percent (based on approximation of the 1997-99 mean SUS incidental rate, as estimated in FRAM). Directed terminal commercial and recreational harvests have not occurred in recent years, and incidental harvest in fisheries directed at coho and pink salmon have been carefully regulated to limit chinook mortality (Table 2).

Direct quantification of the productivity of Dungeness chinook requires either the accumulation of sufficient coded-wire tag recoveries to reconstruct cohort abundance, or an alternate method of measuring freshwater (egg-to-smolt) survival. All fingerlings released by the supplementation program are coded-wire tagged. Recoveries of these tags may, in future, enable cohort reconstruction. However, given the degraded condition of spawning and rearing habitat in the lower mainstem, it must be assumed that natural productivity is critically low. The supplementation program will continue through one full brood cycle (6 years).

The lack of historical tagged production also necessitates the interim use of a representative stock in fishery simulation modeling that informs fishery planning. Tagged Elwha Hatchery fingerlings are incorporated into the FRAM model to estimate the harvest distribution and exploitation rates for all Strait of Juan de Fuca management units. There are also limits on the ability of the FRAM model to accurately depict the harvest distribution and exploitation rates on units with very low abundance. However, the co-managers will continue to develop and promulgate conservation measures that conserve critical management units, while realizing the constraints on quantifying their effects in the simulation model.

Table 2. Spawning escapement and terminal-area harvest of Dungeness River chinook 1986 - 2000.

Return Year	Escapement	Terminal Harvest	Terminal Run
1986	238	9	247
1987	100	4	104
1988	335	5	340
1989	88	1	89
1990	310	0	310
1991	163	19	182
1992	153	1	154
1993	43	1	44
1994	65	0	65
1995	163	0	163
1996	183	0	183
1997	50	0	50
1998	110	0	110
1999	75	0	75
2000	218*	0	218
Average terminal abundance 1996-2000			127

Lacking a direct assessment of the productivity of Dungeness chinook, it is appropriate to examine what is known about other Puget Sound management units with similar life history and similar status. The status of Nooksack River early chinook, in particular the South Fork Nooksack management unit, is also classified as critical, due to chronically low spawning escapement. Degraded habitat is known to constrain freshwater survival in the Nooksack system, as it does in the Dungeness. The recovery exploitation rate of the Nooksack units has been estimated to be 20 percent (NMFS 2000). The harvest objective for Dungeness (i.e., to maintain exploitation in southern U.S. fisheries below 10 percent), implies a total exploitation rate of 20 percent or less, given that approximately half of the harvest of Dungeness chinook may occur in southern fisheries.

The critical escapement threshold for the Dungeness River is 500 natural spawners, which is approximately 50% of the (presumed MSY) escapement goal. Whenever natural spawning escapement for these stocks is projected to be below this threshold, pre-terminal fisheries will be managed to minimize mortality. Until the supplementation program is successful in rebuilding escapement to levels above this threshold, harvest will be constrained, in accordance with Appendix C, to minimize mortality. The current harvest objective of 10 percent exploitation in southern U.S. fisheries reflects this approach.

Data gaps

- Describe freshwater entry timing

- Collect scale or otolith samples to describe the age composition of the terminal run.

- Describe the harvest distribution and estimate fishery-specific exploitation rates from CWT recoveries.

- Estimate marine survival.

- Estimate annual smolt production (i.e. freshwater survival.

13.13 Elwha River Management Unit Status Profile

Component Stocks

Elwha River chinook

Geographic Distribution and Life History Characteristics

Fall chinook spawn naturally in the portions of the lower 4.9 miles of the Elwha River, below the lower Elwha dam, though most of the suitable spawning habitat is below the City of Port Angeles' water diversion dam at RM 3.4. Their productivity is low due to altered and degraded spawning and rearing habitat, and high water temperature during the adult entry and spawning season, which contribute to pre-spawning mortality (ref status reports).

Entry into the Elwha River begins in June and continues through early September. Spawning begins in late August, and peaks in late September and early October (WDF et al 1993). Elwha chinook mature primarily at age-4 (57 percent), with age-3 and age-5 fish comprising 13 percent and 29 percent, respectively, of annual returns (WDF et al 1993, WDFW 1995, PNPTC 1995 cited in Myers et al 1998).

Naturally produced smolts emigrate primarily as subyearlings. Roni (1992) reported that 45 to 83 percent of Elwha River smolts emigrated as yearlings, and 17 to 55 percent as subyearlings, but this study did not differentiate naturally produced smolts from hatchery releases. The Elwha Channel facility no longer releases yearling smolts.

Status

Elwha River chinook were designated as "healthy" in the SASSI document (WDF et al 1993), which considered productivity only in the context of currently usable habitat. In more recent years (see Table 1) Elwha chinook have failed to meet the SASSI criteria for "healthy" status. The stock is a composite of natural and hatchery production. In the Elwha River, chinook production is limited by two hydroelectric dams which block access to upstream spawning and rearing habitat. Recovery of the stock is dependent on removal of the two dams, and restoration of access to high quality habitat in the upper Elwha basin and certain tributaries. Chinook produced by the hatchery mitigation program in the Elwha system are considered essential to the recovery, and are included in the listed ESU.

The comanagers have concluded that recovery of the Elwha stock is not possible unless the dams are removed and access to pristine, productive habitat, which lies largely within Olympic National Park, is restored.

The nominal escapement goal of 2,900 for Elwha River chinook has been achieved, in the absence of in-river fisheries, in three of the past 11 years, but not since 1992. The average escapement over the last three years was 2,030, which is slightly higher than the average of the preceding five years (1992-1996), which was 1,998.

Table 1. Spawning escapement of Elwha River chinook, 1990 – 1999.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3180	3469	3859	1569	1546	1812	1875	2527	2409	1606	2074

Pre-spawning mortality has been a significant factor affecting natural and hatchery production in the Elwha system. High water temperature during the period of freshwater entry and spawning is exacerbated by impoundment of the river behind the two upstream dams. It contributes directly to prespawning mortality, and in some years, promotes the infestation of adult chinook by *Dermocystidium*. Pre-spawning mortality has ranged up to 68% of the extreme terminal abundance (Table 2), largely due to parasite infestation.

Table 2. Prespawning mortality of Elwha River chinook.

Return Year	Hatchery Voluntary Escapement	In-River Gross Escapement	Gaff-Seine Removals	Hatchery Prespawn Mortality	In-River Prespawn Mortality	Total Prespawn Mortality
1986	1,285	1,842	505	376	482	27%
1987	1,283	4,610	1,138	432	1,830	38%
1988	2,089	5,784	506	428	50	6%
1989	1,135	4,352	905	148	412	10%
1990	586	2,594	886	160	64	7%
1991	970	2,499	857	108	N/A	3%
1992	97	3,762	672	26	2,611	68%
1993	165	1,404	771	7	0	0%
1994	365	1,181	749	61	269	21%
1995	145	1,667	518	37	625	37%
1996	214	1,661	1,177	147	120	14%
1997	318	2,209	624	3	7	0%
1998	138	2,322	1,689	51	0	2%
1999	117	1,512	699	27	0	2%
2000	223	1,851	1,021	21	0	1%

Harvest Distribution

Elwha River chinook are a far-north migrating stock, as evidenced by substantial fishing mortality occurring in past years in Alaskan and northern British Columbian fisheries (Table 3),though not to the extent exhibited by Washington coastal stocks. More recent analyses are not available, but it is likely that fishing mortality in northern B.C. and the west coast of Vancouver Island have been much reduced due to restriction of those fisheries since 1996.

Table 3. The average distribution of adult equivalent annual fishing mortality for Elwha River chinook for 1986 – 1990 and 1991 – 1996 (CTC 1996).

	AK.	NCBC	WCVI	Georgia Strait	BC Net &Sport	Wa. Troll	PS Net	WA. Sport
1986 - 90	18.5%	20.6%	25.7%	4.0%	1.8%	3.5%	11.5%	14.4%
1991 - 96	9.8%	10.2%	27.6%	10.2%	6.9%	4.9%	9.0%	21.3%

Management Objectives

Fisheries in Washington waters, including those under jurisdiction of the Pacific Fisheries Management Council, when the escapement goal is not projected to be met, will be managed so as not to exceed a ‘Southern U.S.’ exploitation rate of 10 percent on Elwha chinook (based on approximation of the 1997-99 mean SUS incidental rate, as estimated in FRAM). Harvest at this level will assist in providing adequate escapement returns to the river to perpetuate natural spawning in the limited habitat available, and provide broodstock for the supplementation program. It represents a significant decline in harvest pressure from southern U.S. fisheries. The SUS exploitation rate on the Strait of Juan de Fuca management unit aggregate averaged 41 percent for management years 1990 – 1996. Actual exploitation rates for more recent years have not been calculated, however they were projected to be 7 percent and 8 percent, respectively, in the final pre-season FRAM simulation models for management years 1999 and 2000.

The critical escapement threshold for the Elwha River is 1,000 spawners, which represents a composite of 500 natural and 500 hatchery spawners. Whenever spawning escapement for this stock is projected to be below these levels, fisheries will be managed to achieve a lower rate in southern U.S. waters, in accordance with base fishery levels specified in Appendix C.

Table 4. Abundance of Elwha River chinook entering Puget Sound fishing areas (4B run), pre-terminal harvest, and the size of the run entering the Elwha River (terminal run), 1988 - 1999 (PNPTC et al 2001 PSF Report).

Return Year	Area 4B Run	Pre-terminal Catch	Terminal Run
1988	9,083	417	8,666
1989	5,816	113	5,703
1990	3,644	39	3,605
1991	3,824	63	3,761
1992	4,056	54	4,002
1993	1,695	26	1,669
1994	1,622	42	1,580
1995	1,852	38	1,814
1996	1,884	7	1,877
1997	2,571	43	1,330
1998	2,469	7	2,462
1999	NA	NA	1,629
2000	NA	NA	2,074
1993-98 Mean	2,016	27	
1993-2000 Mean			1,804

Data Gaps

- Estimates of natural smolt production from the lower Elwha River.
- Estimates of the age composition and description of life history of smolts.

13.14 Status Profile for the Western Strait of Juan de Fuca Management Unit

Component Stocks

Hoko River fall chinook

Geographic description

Fall chinook spawn primarily in the mainstem of the Hoko River, from above intertidal zone to RM 22, but primarily between RM 3.5 (the confluence of the Little Hoko River) to the falls at RM 10. Chinook may ascend the falls and spawn in the upper mainstem up to RM 22, and the lower reaches of larger tributaries such as Bear Creek (RM 0 to 1.2) and Cub Creek (RM 0 – 0.8), Ellis Creek (0 – 1.0), the mainstem (RM 0 – 2.5) and North Fork (RM 0 – 0.37), of Herman Creek, and Brown Creek(0 – 0.8). Chinook also spawn in the lower 2.9 miles of the Little Hoko River. Historically, chinook have also spawned in other Western Strait streams, including the Pysht, Clallam, and Sekiu rivers. Recent surveys of the Sekiu counted 52 and 12 chinook in 1998 and 1999, respectively. Their origin is unknown, but they area assumed to be strays from the Hoko system.

Currently, chinook from the Hoko Hatchery are being outplanted into the upper Hoko mainstem and tributaries of the upper and lower portions of the watershed, to seed high quality habitat, which has not been utilized consistently for spawning or rearing. Re-introduction to the Sekiu River, and other western Strait streams that once supported chinook, is also being planned.

Life History Traits

Based on scales collected from natural spawners and broodstock from 1988 – 1999, returning Hoko River adults are predominately age 4 (31%) and age 5 (49%), with age 3 and age 6 adults comprising 8% and 10%, respectively, of the average age composition (MFM 2000. The data available suggest that most smolts produced in the Hoko system emigrate as subyearlings (Williams et al cited in Myer et al 1998), but a small but consistent proportion of juveniles overwinter in freshwater (MFM unpublished data).

Status

The established escapement goal for Hoko River chinook is 850 natural spawners (*i.e.* spawning in gravel). This goal, first presented in 1978 in WDF *Technical Report 29*, is based on early estimates of freshwater habitat capacity. For the Hoko chinook stock as a whole, combined spawning escapement (natural plus hatchery) has averaged 971 spawners from 1988 through 1999. Nearly half the Hoko River natural spawners in most years may be attributed to the supplementation program (MFM 2000). As Table 1 shows, the escapement goal for natural spawners has been achieved in only four out of the 12 years from 1988 to 1999. The natural spawning escapement during these past four years (1,278 natural spawners) has well exceeded the goal of 850 while allowing for additional spawners to be collected for hatchery brood stock during this

Table 1. Natural spawning escapement of chinook and hatchery broodstock removals from the Hoko River, 1988 – 1999.

Return Year	Natural Spawners	Hatchery Brood Stock	Total
1988	686	90	776
1989	775	67	842
1990	378	115	493
1991	894	112	1,006
1992	642	98	740
1993	775	119	894
1994	332	96	428
1995	750	155	905
1996	1,227	38	1,265
1997	768	126	894
1998	1,618	97	1,715
1999	1,497	193	1,690
Average:	862	109	972
Goal:	850	200	1,050

Although the escapement goals set in Technical Report 29 have been commonly accepted over the past two decades, it is not clear that 850 is the optimum chinook escapement level for the Hoko River. Further analysis of habitat suitability and usage should be conducted to determine whether spawning or rearing habitat limits chinook production in the Hoko.

Harvest Distribution and Exploitation Rate Trends

The migration pathway, and harvest distribution, of Hoko River chinook has been described from recoveries of coded-wire tagged fish released from the Hoko Hatchery. The tag data suggest that Hoko chinook are harvested by coastal fisheries in Southeast Alaska, British Columbia, and Washington, as well as in Puget Sound. A preliminary analysis of tag data also estimates fisheries exploitation rates (MFM 2000), though this cohort reconstruction has not yet accounted for natural and non-landed fisheries mortality.

Table 2. Fishery exploitation rates for Hoko River chinook estimated from recoveries of coded-wire tags in fisheries and escapement (MFM 2000).

Brood Year	Exploitation Rate		
	Total	BC & AK	WA
1985	0.61	0.41	0.20
1986	0.61	0.46	0.15
1987	0.55	0.46	0.09
1988	No CWT data		
1989	0.48	0.46	0.02
1990	0.36	0.34	0.02
1991	0.26	0.25	0.01
1992	0.15	0.14	0.001
1985 - 90 average	0.52	0.43	0.10
1991 - 92 average	0.21	0.20	0.01

The total exploitation rates for Hoko chinook have declined considerably, from over 60 percent in the 1980's, to 20 percent in more recent years. The Hoko rate shows a similar, but more pronounced, decline to that observed for other Puget Sound chinook stocks (Table 3).

Table 3. Comparison of total fishery exploitation rates among Puget Sound chinook stocks (unpublished CTC analysis cited in NMFS 2000)

Stock	Average total fisheries exploitation rate	
	Brood years 1977 – 1990	Brood years 1991 - 1994
Nooksack early	.61	.43
Skagit spring	.68	.50
White River spring	.69	.49
Stillaguamish summer	.67	.48
Green River fall	.73	.43
Nisqually fall	.86	.70
Skokomish fall	.87	.42

It could be expected that an average exploitation rate of 42 percent experienced by Hoko chinook of broods 1986 through 1991 would at least allow for replacement of spawners. Hoko chinook were fished at a rate that should be reasonable for Puget Sound chinook stock productivity, but their stock productivity was so low during the 1985-1992 brood year period, that even this modest exploitation rate was higher than would allow for replacement of spawners. This low productivity of Hoko chinook is very likely related to degraded freshwater habitat, including recurrent flooding and erosion, with poor marine survival.

Management Objectives

Management guidelines include a recovery exploitation rate objective for the Western Strait of Juan de Fuca management unit and a critical escapement threshold. The recovery exploitation rate objective is a maximum of ten percent in southern U.S. fisheries. It represents a lower exploitation rate than these stocks have experienced on average, and a rate that is achievable (and has been achieved in recent years), through conservative fishery management (Table 2). Recent years have shown that the nominal escapement goal can be achieved, with favorable marine survival, under this management regime.

The critical escapement threshold for the Hoko River is 500 natural spawners. Whenever natural spawning escapement for these stocks is projected to be below these levels, the harvest management plan may call for fisheries to be managed to achieve a lower rate than the interim ten percent exploitation rate objective.

Data gaps

- Reconstruct more recent brood years from CWT data
- Derive a spawner/recruit relationship for Hoko chinook
- Stock origin of spawners in other Strait streams.

14 Appendix B – Pre-season PST Assessment Procedure

Conservation objectives for natural management units will react to the expected abundance and spawning escapement. Stepped reductions will occur when a management unit is projected not to achieve its conservation objective. These reductions will comply with the passthrough provisions and general obligations for individual stock-based management regimes (ISBM) pursuant to the chinook annex within the US/Canada Pacific Salmon Treaty.

The chinook FRAM is ran with the current year's abundance forecasts and the proposed fishery regulation package. Forecasted escapement and the total exploitation rate for each management unit then are assessed. If the PSC escapement threshold standard[1] has not been met, then the US exploitation rate is constrained to 60 percent of 1979-1982 mean southern US non-ceiling index or 1991-1996 average reduction relative to the southern US non-ceiling index, whichever is less[2]. The state and tribes can agree to a lower rate. The calculation is expressed as follows:

$$[(E_{mod} > E_T) \text{ v } (U_{SUSmod} \leq U_{SUS79\text{-}82}{*}0.60 \wedge U_{SUSmod} \leq U_{SUS91\text{-}96})]$$

Where U is exploitation rate; U_{mod} is modeled total exploitation rate; E_{mod} is the modeled escapement; E_T is the PSC escapement threshold; SUS is the Southern United States; 79-82 is the 1979-82 mean; and 91-96 is the 1991-96 average reduction relative to the base period. Also, "^" is the logical "And", and "v" is the logical "Or".

[1] The PSC escapement threshold standards reflect MSY or other biologically based escapement objectives.

[2] These step reductions are reflective of the weak stock gates established for ISBM fisheries within the chinook annex of the US/Canada Pacific Salmon Treaty. The US non-ceiling index as defined in TChinook (96)-1 will be used to measure performance of ISBM fisheries (PSC 1996). Although for domestic management purposes the assessment is conducted on a stock-by-stock basis, not on an indicator stock group basis as assessed within the Pacific Salmon Treaty process.

15 Appendix C – Minimum Fishery Regulation Regime

The set of fishery regulations described in this appendix defines the co-managers' minimum fishery regulation regime. This regime will be evaluated annually, at forecast abundance for all management units, using pre-season fishery models (e.g., FRAM) to set an exploitation rate for each management unit that is expected to have spawner abundance less than its low abundance threshold. This process also will define the maximum southern U.S. exploitation rate for those management units. Southern U.S. fisheries will be structured during the pre-season planning process to achieve a modeled exploitation rate no greater than this defined rate.

This low abundance, exploitation rate objective will vary annually, dependent upon changes in the relative abundance of U.S. and Canadian chinook and in northern fishery regimes. Appendix C outcomes are sensitive to changes in effort, abundance of other species, and the relative abundance of the critical management unit(s) in comparison to the other chinook stocks.

To quantify its effect, the minimum fishery regulation regime was modeled at recent Puget Sound chinook abundance. The range of exploitation rates that resulted reflects, to some extent, the slightly increased incidental impacts associated with odd-year fisheries for pink salmon, but likely understates the range that will emerge from this modeling exercise in future years. The past circumstances do not provide certainty of capturing all possible future possibilities.

Low abundance exploitation rate objectives are summarized below (Table C-1), either as total exploitation rates or southern U.S. exploitation rates, in comparison to recovery – level objectives that apply at higher abundance. Where terminal fisheries regimes will be managed to achieve specific escapement objectives, as described in the management unit status profiles, the low abundance rate is expressed only for pre-terminal southern U.S. (SUS) fisheries.

Table C-1. Range of exploitation rates (ER) expected with application of the Minimum Fishery Regulation Regime, under assumptions of recent year stock and species abundance.

Natural Chinook Management Units	Recovery Exploitation Rate Ceiling	Appendix C Ranges
Western Strait – Hoko R	10% SUS ER	8 – 10% SUS ER
Elwha River	10% SUS ER	8 – 10% SUS ER
Dungeness	10% SUS ER	8 – 10% SUS ER
Mid-Hood Canal	15% pre-terminal SUS ER Terminal – 750 spawners	13 – 15% pre-terminal SUS ER plus terminal [1]
Skokomish	15% pre-terminal SUS ER Terminal – 3,150 spawners	12 - 15% pre-terminal SUS ER plus terminal [1]
Nooksack Early	Under development[2]	5 – 7% SUS ER
Skagit Spring	42% Total ER	15 - 17% SUS or 21-23% Total ER
Skagit Summer/Fall	52% Total ER	12 - 17% SUS or 29-33% Total ER
Stillaguamish Summer/Fall	25% Total ER	9 - 10% SUS or 15-16%Total ER
Snohomish Summer/Fall	32% Total ER	19 - 20% SUS or 24-26% Total ER
Lake Washington Cedar R	15% pre-terminal SUS ER Terminal – 1,200 spawners	11 - 15% pre-terminal SUS ER plus terminal [1]
Green River	15% pre-terminal SUS ER Terminal – 5,800 spawners	10 - 15% pre-terminal SUS ER plus terminal [1]
White River Spring	17% Total ER	12% SUS or 13% Total ER
Puyallup River	50% Total ER	26% SUS or 36% Total ER
Nisqually River	1,100 spawners	Terminal [1]

[1] The management intent is to take necessary action in the terminal and pre-terminal fisheries to achieve the low abundance threshold or to maximize the spawning escapement given the maximum regulatory effect that can be achieved for the management unit. Refer to the stock profiles for details on management intent.

[2] The co-managers and NMFS are currently working on developing a recovery exploitation rate ceiling for this management unit. For the next two years it is not expected that the abundance of natural origin spawners will exceed the low abundance threshold. Therefore it is anticipated that southern US fisheries will be managed at impact levels generated from the application of Appendix C.

Minimum Fishery Regulation Regime

Non-Treaty Ocean Troll Fishery:

- A ceiling catch number of 5,900 chinook.
- Area 3 and 4 closed.

Non-Treaty Ocean Recreational Fisheries:

- A ceiling catch number of 3,500 chinook.
- Chinook non-retention in Areas 4 and 4B.

Treaty Ocean Troll Fishery:

- A ceiling catch number of 15,000 chinook.
- Chinook only May 1 through June 30.
- All species July 1 through earlier of September 15 or ceiling.

Strait of Juan De Fuca Treaty Troll Fisheries:

- Open June 15 through April 15.
- Use barbless hooks only.

Strait of Juan De Fuca Treaty Net Fisheries:

- Setnet fishery for chinook open June 16 to August15. 1000 foot closures around river mouths.
- Gillnet fisheries for sockeye, pink, and chum defined by PST Annex; net fisheries closed mid-November through mid-June.

Strait of Juan De Fuca Non-treaty Net Fisheries:

- Closed year-around.

Area 5/6 Recreational Fishery:

- May 1-July 31 closed.
- Chinook non-retention August and September.
- October closed
- 1-chinook bag limit in November.
- December-February 15 closed
- 1-fish bag limit February 16-April 10
- April 11-30 closed

Strait of Juan De Fuca Terminal Treaty Net Fisheries:

- Hoko, Pysht, and Freshwater Bays closed May 1 – October 15.
- Elwha River closed March 1 through mid-September.
- Dungeness Bay closed March 1 through mid-September.
- Area 6D chinook non-retention mid-September through October 10.
- Close miscellaneous JDF streams March 1 through November 30.

Strait of Juan De Fuca River Recreational Fishery:

- Chinook non-retention in Elwha.
- Dungeness closed to salmon 12/1 through 10/15.
- Dungeness chinook non-retention 10/16 through 11/30.
- Close other streams.

Area 6/7/7A Treaty – Non-treaty Net Fisheries:

- Sockeye, Pink, and chum fisheries as defined by PST Annex provisions with the following adjustment measures;
- Net fisheries closed from mid-November through mid-June.
- Close Area 6A.
- Non-treaty purse seine and reef net fisheries chinook non-retention.
- Non-treaty gillnet fishery chinook ceiling of 700.
- Non-treaty closure within 1500 feet of Fidalgo Island between Deception Pass and Shannon Pt; and within 1500 feet of Lopez and Decatur Islands between Pt Colville and James Island.
- Preseason catches in 1999 used for Jul-Sep in pink years; 2000 for nonpink years

Area 7 Recreational Fishery:

- May 1-June 30 closed.
- 7/1-7/31 1 fish limit, Rosario Strait and Eastern Strait of Juan de Fuca closed; Bellingham Bay closed.
- 8/1-9/30 1 fish limit, Southern Rosario Strait and Eastern Strait Juan de Fuca closed Bellingham Bay closed.
  8/1-8/15, Samish Bay closed.
- Chinook non-retention 10/1-10/31
- 11/1-11/30 1 fish limit.
- December-February 15 closed
- 1-fish bag limit February 16-April 10
- April 11-30 closed

Nooksack/Samish Terminal Area Fisheries:

- Closed to commercial fishing from April 15 through July 31 when either early run does not exceed 1,000 spawners.
- Closed to commercial fishing from April 15 through June 30 when both early runs exceed 1,000 spawners, but at least one run does not exceed 2,000 spawners.
- Ceremonial fishery in late May limited to 5 fish when either early run does not exceed 1,000 spawners.
- Additional ceremonial fisheries and subsistence fisheries limited to July 1-4 when either early run does not exceed 1,000 spawners.
- Bellingham Bay recreational fishery closed in July.
- Samish Bay recreational fishery closed August 1-15.
- Chinook non-retention in Nooksack River recreational fisheries.
- 2-chinook bag limit after October 1 in Nooksack River.
- 2-fish bag limit from July 1 to December 31 in Samish River.

Skagit Terminal Area Net Fisheries:

- Skagit Bay and lower Skagit River closed to net fishing from mid-February to August 22 in pink years, and until week 37 (~September 10) in non-pink years.
- Upper Skagit River closed to commercial net fishing from mid-March to August 22 in pink years, and until week 42 (~October 10) in non-pink years, unless there is an opening for Baker sockeye in July.
- Upper Skagit and Sauk-Suiattle fisheries on Baker sockeye require 5½ " maximum mesh, and chinook non-retention.
- Half of the Upper Skagit and Sauk-Suiattle share of Baker sockeye will be taken at the Baker Trap, rather than in river fisheries.
- No chinook update fishery or directed commercial chinook fishery.
- Treaty pink update fishery limited to 2 days/week during weeks 35 and 36, and Non-treaty update limited to 1 day/week, gillnets only.
- Pink fishery gillnet openings in the Skagit River limited to a maximum of 3 days/week, regardless of pink numbers. Beach seines may be used on other days, with chinook non-retention.
- Up to 40% of the Upper Skagit share of pink salmon will be taken in Skagit Bay.
- Release chinook from beach seines in Skagit Bay.
- Chinook non-retention required in pink fisheries in the upper river.
- No Non-treaty commercial coho openings in Skagit Bay.
- Tribal coho openings delayed until Week 39 in the Bay and lower river, and until Week 42 in the upper river.
- Chinook test fisheries limited to 1 boat, 6 hrs/week.

Skagit River Recreational Fisheries:

- Chinook non-retention.

Area 8A and 8D Net Fisheries:

- Area 8A Treaty fishery chinook impacts incidental to fisheries directed at coho, pink, chum, and steelhead.
- Treaty pink fishery schedule limited to maintain chinook impacts at or below modeled rate.
- Area 8A non-treaty fishery chinook impacts incidental to fisheries directed at pink and chum.
- Non-treaty pink fishery limited to 1 day/week for each gear.
- Non-treaty purse seine fishery chinook non-retention.
- Area 8D Treaty chinook fisheries limited to C & S in May and June, and to 3 days/wk in July, August, and September.
- Area 8D non-treaty chinook impacts incidental to fisheries directed at coho and chum.

Stillaguamish River Net Fisheries:

- Treaty net fishery chinook impacts incidental to fisheries directed at pink, chum, and steelhead.
- Treaty pink fishery schedule limited to maintain chinook impacts at or below modeled rate.

Stillaguamish River Recreational Fisheries:

- Chinook non-retention.
- Use barbless hooks from September 1 to December 31.

Snohomish River Fisheries:

- Net fisheries closed.
- Chinook non-retention in river recreational fisheries.

Area 8-1 Recreational Fisheries:

- 5/1-8/31 closed.
- Chinook non-retention 9/1-10/31.
- 11/1-11/30 1 fish limit.
- 12/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.

Area 8-2 Recreational Fisheries:

- 5/1-7/31 closed.
- Chinook non-retention 8/1-10/31.
- 11/1-11/30 1 fish limit.
- 12/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.
- 1-chinook bag limit in Tulalip Bay in August and September.
- Tulalip Bay openings limited to 12:01 AM Friday to 11:59 AM Monday each week.

Area 9 Net Fisheries:

- Net fisheries limited to research purposes.

Area 9 Recreational Fisheries:

- 5/1-7/31 closed.
- Chinook non-retention 8/1-10/31.
- 11/1-11/30 1 fish limit.
- 12/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.

Area 10 Net Fisheries:

- Closed from mid-November through June and August. Limited fishery in July possible only in years when harvestable Lake Washington sockeye are available.
- Treaty net fisheries chinook impacts incidental to fisheries directed at coho, and chum.
- Non-treaty coho fishery closed.
- Non-treaty purse seine fishery chinook non-retention.

Area 10A Treaty Net Fisheries:

- Limit chinook gill net fisheries to 3 test fishery openings and 1 day/wk update fisheries.
- Net fishery chinook impacts incidental to fisheries directed at coho, chum and steelhead, with coho opening delayed until chinook clear.

Area 10E Treaty Net Fisheries:

- Closed from mid November until last week of July.
- Chinook net fishery 5 day/wk last week of July through September 15.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Duwamish/Green River Fisheries:

- Chinook net fishery limited to 1 day/wk update fishery until run size updated.
- Net fishery chinook impacts incidental to fisheries directed at coho and steelhead. Coho fishery closed until chinook clear.
- Chinook non-retention in river recreational fisheries.

Lake Washington Terminal Area Fisheries:

- Net fishery chinook impacts incidental to fisheries directed at coho and sockeye. Coho net fisheries delayed until chinook clear.
- Cedar River and Issaquah Creek closed to recreational fishing.
- Chinook non-retention in Sammamish River, Lake Washington, Union, Portage Bay, and Ship Canal recreational fisheries.

Area 10 Recreational Fisheries:

- 5/1-6/30 closed.
- Chinook non-retention 7/1-10/31.
- 11/1-11/30 1 fish limit.
- 12/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.

Area 11 Net Fisheries:

- Closed from end of November to beginning of September.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.
- Non-treaty purse seine fishery chinook non-retention.

Area 11A Net Fisheries:

- Closed from beginning of November to end of August.
- Net fishery chinook impacts incidental to fisheries directed at coho.

Puyallup River System Fisheries:

- Net fisheries closed from beginning of February to beginning of August.
- Limit gill net test fishery for chinook to 1 day a week, scheduled from mid-July through the end of August.
- Chinook net fisheries limited to 1 to 3 days/week and delayed until August 15 to protect White River spring chinook.
- Muckleshoot on-reservation fisheries on White River limited to hook and line C & S fishing for seniors, with a limit of 25 chinook.
- Net fishery chinook impacts incidental to fisheries directed at coho, chum, and steelhead.
- 2-chinook bag limit in river sport fisheries.
- Chinook non-retention before August 1 in Puyallup River sport fishery.
- Chinook non-retention before September 1 in Carbon River sport fishery.
- Chinook non-retention in White River.

Area 11 Recreational Fisheries:

- 5/1-5/30 closed.
- 1-fish limit June 1 – November 30.
- 12/1-2/15 closed.
- 1-fish limit February 16 – April 10.
- 4/11-4/30 closed.

Fox Island/Ketron Island Net Fisheries:

- Closed from end of October to August 1.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Sequalitchew Net Fisheries:

- Net fishery chinook impacts incidental to fisheries directed at coho.

Carr Inlet Net Fisheries:

- Closed from beginning of October through August 1.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Chambers Bay Net Fisheries:

- Closed from end of mid-October to August 1.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Area 13D Net Fisheries:

- Closed from mid-September to August 1.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Henderson Inlet (Area 13E) Net Fisheries:

- Closed year-around.

Budd Inlet Net Fisheries:

- Closed from mid-September to July 15.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Areas 13G-K Net Fisheries:

- Closed Mid-September to August 1.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.

Nisqually River and McAllister Creek Fisheries:

- Net fishery closed late September to late June.
- Chinook net fishery limited to 3 days/week.
- Net fishery chinook impacts incidental to fisheries directed at coho and chum.
- Nisqually River recreational closed February 1 through May 31.
- McAllister Creek recreational closed December 1 through May 31.
- Chinook non-retention in June recreational fishery.
- 2-chinook bag limit.

Area 13 Recreational Fisheries:

- 1-fish bag limit May 1-November 30.
- 12/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.

Hood Canal (12, 12B, 12C, 12D) Net Fisheries:

- Non-treaty fishery closed from end of November to mid-October.
- Hoodsport Hatchery Zone open in August to hook and line gear, and to beach seines.
- Chinook directed treaty fishery limited to Area 12C.

Area 9A Net Fisheries:

- Closed from end of January to beginning of September (Dependent upon pink fishery).

Area 12A Net Fisheries:

- Closed from mid-December to mid-August.
- Beach seines and hook & line gear chinook non-retention.
- Non-treaty limited to beach seines only.

Area 12 Recreational Fishery:

- 5/1-6/30 closed.
- Chinook non-retention 7/1-10/15.
- 10/16-12/31 1-fish limit.
- 1/1-2/15 closed.
- 1-fish bag limit February 16 – April 10.
- 4/11-4/30 closed.

Hood Canal Freshwater Net Fisheries:

- Close Dosewallips, Duckabush, and Hamma Hamma.
- Skokomish River chinook fishery starting August 1 limited to 2 to 5 days/week.

Hood Canal Freshwater Recreational Fisheries:

- Closed March 1 to May 31.
- Chinook non-retention from June 1 to February 29 in all rivers.
- Dosewallips, Duckabush, and Hamma Hamma closed in September and October.

16 Appendix D – Research and Monitoring Programs

The Northwest Washington Indian Tribes and the Washington Department of Fish and Wildlife (WDFW), independently and jointly conduct a variety of research and monitoring programs that provide the technical basis for fisheries management. These activities were mandated by the Puget Sound Salmon Management Plan in 1985, though activities related to chinook management have evolved as management tools have improved. Monitoring and assessment essential to the management of Puget Sound chinook is described in detail below, with discussion of how the information is used to validate and improve management regimes. This is not an exhaustive inventory of chinook research. A wide variety of other studies are underway to identify factors that limit chinook production in freshwater, and to monitor the effectiveness of habitat restoration.

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Monitoring catch and fishing effort

Chinook harvest in all fisheries, including incidental catch, and fishing effort are monitored and compared against pre-season expectations. Commercial catch in Washington waters is recorded on sales receipts (‘tickets’), copies of which are sent to WDFW and tribal agencies. Cumulative catch may be tracked in-season from summary of these tickets, and is recorded in a jointly-maintained database. A reliable summary of catch and effort is available four months after the season, though a final, error-checked record may require a year or more to develop.

Catch and effort are estimated in-season for certain chinook fisheries that are limited by catch quotas, such as the ocean troll and recreational fisheries that are managed under the purview of the Pacific Fisheries Management Council.

Recreational catch may be estimated in-season by creel surveys, sampling regimes for which have been developed to meet the standards of variance for weekly catch. However, for most Washington fishing areas, recreational harvest is estimated from a sample of catch record cards obtained from all anglers. The recreational fishery baseline sampling program provides auxiliary data for the Salmon Catch Record Card System: species composition to estimate recreational harvest by species and CPUE (salmon per angler trip) to estimate total effort. The baseline sampling program is geographically stratified among Areas 5-13 in Puget Sound. Sampling size is set at 120 fish per stratum for estimation of species composition and 100 boats per stratum for the estimation of CPUE.

Catch and effort summaries allow an assessment of the performance of fishery regulations in constraining catch to the desired levels. Time and area constraints, and gear limitations, are imposed by regulations, but with some uncertainty of their exact effect on harvest. For many fisheries, catch is often projected preseason based on the presumed effect of specific regulations. Post-season comparison to actual catch assesses the true effect of those regulations, and guides their future application or modification.

Incidental catch has comprised an increasingly significant part of total chinook harvest mortality. For many commercial net fisheries in Puget Sound, incidental catch is projected by averaging a recent period, either as total chinook landed or as a proportion of the target species catch. Thus, the most recent years' data are an essential part of these projections.

Incidental mortality of chinook may also be significant for commercial troll and recreational hook-and-line fisheries, regulation for which may mandate release of sub-adult chinook, or all chinook, during certain periods. Studies are periodically undertaken to estimate encounter rates and hooking mortality for these fisheries. Findings from these studies are required to validate the encounter rates and release mortality rates used in fishery simulation models.

Coded-wire Tag Sampling

Commercial and recreational catch in all marine fishing areas in Washington are sampled to recover coded-wire tagged chinook. For commercial fisheries, the objective is to sample at least 20% of the catch in each statistical week, throughout the fishing season. For recreational fisheries, the objective is to sample 10% of the catch in monthly strata. Scales to enable age determination, and other biological data, may also be collected from catch in certain fisheries.

For chinook, a clipped adipose fin has signaled the presence of a coded-wire tag.
To the extent possible, randomly selected sub-samples of catch are visually examined for fin clips. Snouts are removed from marked chinook and sent, with sampling records, to a central facility operated by WDFW, where the wire tags are removed and read. If, in future, hatchery-produced chinook are mass-marked with an adipose fin clip, the presence of coded-wire tags will be detected electronically. Tag detection equipment has been developed and put into use for sampling coho, for which a majority of hatchery production in Washington is currently mass marked. Efforts are underway to apply this technology to sampling chinook. Electronic tag detection will also be required for sampling chinook escapement.

Spawning escapement estimation

Spawning escapement for Puget Sound units is estimated from surveys of index reaches in each river system (Table D-1). A variety of computational methods are used to calculate escapement, including cumulative redd counts, peak counts of live adults, cumulative carcass counts, and integration under escapement curves drawn from a series of live fish or redd counts.

Escapement surveys also provide the opportunity to collect biological data from adults to determine their age, length, and weight, and to recover coded-wire tags. Tissue or otolith samples may be used to determine whether they are of hatchery or wild origin, and coded wire tags or otoliths may be used to identify strays from other systems. Depending on the accuracy required of such estimates, more sampling effort may be required than has previously been expended on gathering basic biological data to determine age and sex composition. State and tribal technical staff are currently focusing attention on the design and implementation of these studies.

Table D-1. Index areas surveys to estimate chinook spawning escapement in the Puget Sound rivers.

WRIA	System	No. reaches	Freq.	Duration
Nooksack River	Lower Mainstem	5	1 – 12	July 27 – Oct 31
	South Fork	4	1 – 4	
	Middle Fork	3	1 – 6	
	North Fork	8	1 – 10	
	Samish R.	2	1	
Skagit River	Lower Mainstem	2	1 – 4	July 23 – Oct 31
	Finney Cr.	2	1 – 4	
	Upper Mainstem	1	1	
	Sauk R.	10	1 – 6	
	Suiattle R.	10	1 – 15	
	Cascade R.	12	1 – 5	
Stillaguamish River	Lower Mainstem	3	1 – 9	Aug 19 – Nov 10
	Pilchuck Cr.	1	3	
	North Fork	6	1 – 18	
	Deer Cr.	1	1	
	Boulder Cr.	1	5	
	Squire Cr.	1	6	
	Deer Cr.	1	1	
	Jim Cr.	1	4	
	Canyon Cr.	3	2	
Snohomish River	Lower Mainstem	6	3	Sept 8 – Nov 12
	Pilchuck R.	1	1	
	Snoqualmie R.	3	1 – 5	
	Tolt R.	2	4	
	Raging R.	1	5	
	Skykomish R.	3	5 – 7	
	Wallace R.	4	1 – 8	
Lake Washington	Sammamish River	6	13	Aug 2 – Dec 11
	Issaquah Creek	3	1 - 7	
	Cedar River	6	1 - 15	
Duwamish/Green River	Duwamish R.	4	1 – 6	Sept 16 – Oct 23
	Newaukum Cr.	2	6	
Puyallup River	Lower Mainstem	2	2 – 5	Aug 19 – Nov 6
	White R.	8	1 – 6	
	Greenwater	2	9	
	Mainstem	1	2	
	Carbon R.	1	5	
	South Prairie Cr.	8	1 – 8	
	Upper Puyallup	2	1	
South Puget Sound	Kennedy Cr.	1	1	Sept 16 – Oct 31
	Mill Cr.	1	1	
	Goldsborough Cr.	1	4	
	Cranberry Cr.	1	1	
	Deer Cr.	1	5	
	Sherwood Cr.	1	5	

Table D-1. (continued). Chinook spawning escapement surveys within the Puget Sound.

Kitsap Peninsula	Coulter Cr.	1	6	Aug 25 – Nov 10
	Rocky Cr.	1	7	
	Burley Cr.	2	3	
	Curley Cr.	1	1	
	Blackjack Cr.	2	3	
	Gorst Cr.	1	6	
	Chico Cr.	1	1	
	Clear Cr.	1	3	
	Barker Cr.	1	1	
	Dogfish Cr.	1	4	
	North Kitsap Un-named	1	2	
Hood Canal	Dewatto R.	1	6	Sep 3 – Nov 5
	Tahuya R.	1	1	
	Union R.	1	7	
East Olympic Peninsula (Hood Canal)	Skokomish Mainstem	9	1 – 5	Aug 3 – Nov 3
	Skokomish North Fork	1	1	
	Hamma Hamma R.	2	6	
	Duckabush R.	1	3	
	Dosewallips R.	4	1 – 5	
Strait of Juan de Fuca	Dungeness Mainstem	10	1 - 12	Sept 25 – Nov 6
	Greywolf R.	3	1 - 7	
	Upper Greywolf	3	4 - 7	
	Elwha R.	1	11	
	Hoko R. mainstem	10	4 - 6	
	Hoko R. tribs.	7	4 – 6	

Escapement surveys also describe the annual variation in the return timing of chinook populations. Given that terminal-area fisheries for chinook have been highly restricted or eliminated throughout Puget Sound, escapement surveys are increasingly relied on to monitor run timing, as well as age composition.

Reconstructing Abundance and Estimating Exploitation Rates

Escapement estimates and coded-wire tag data enable estimation of the abundance of annual chinook returns, and given the age composition of annual returns, estimation of the abundance of all cohorts produced from a given brood year escapement. After adjustment to account for non-landed and natural mortality, these estimates of recruitment define the productivity of specific populations. The principal intent of the current chinook harvest management regime is to set management unit objectives based on the current productivity of their component populations. These objectives will change over time, therefore, in response to increase or decline in productivity.

The productivity of Puget Sound chinook populations is estimated as the sum of spawning escapement and harvest mortality inferred from tagged indicator stocks. Methods have not been developed for tagging wild chinook smolts, with low handling mortality, and in sufficient numbers to describe catch distribution and harvest mortality. As a result hatchery indicator stocks have been developed for Puget Sound, as part of a coastwide indicator stock program with oversight by the Pacific Salmon Commission. To the extent possible these hatchery indicator stocks programs release tagged juveniles with the same genetic and life history characteristics as the wild stocks that they represent. Exploitation rate indicator stock programs, in general, release 200,000 tagged juveniles annually. If all intercepting fisheries are sampled at the target rate of 20%, tag recoveries will be sufficient to estimate harvest distribution and total exploitation rate.

Coded-wire tag data enables the calculation of total, age-specific fishing mortality, and mortality in certain fishery aggregates. These estimates of fishery mortality may be compared with those made by fishery simulation models as a check on model accuracy. The FRAM model, for example, runs on projections of abundance and expected fishery-specific mortality which are scaled against base year abundance and fisheries. It is recognized that the model cannot perfectly simulate the outcome of the coast-wide chinook fishing regime. The migration routes of chinook populations may vary annually, and the effect of changing fisheries regulations cannot be perfectly predicted in terms of landed or non-landed mortality. Tag recoveries from a given year provide an independent basis for estimating harvest mortality of particular stocks. Periodically, the bias in simulation modeling will be assessed. Harvest objectives for individual management units incorporate this source of management error (i.e. the average difference between the simulation model and tag-based estimates of harvest mortality), to insure that Puget Sound units are not overharvested. As simulation models evolve they are expected to rely on code-wire tag data from more recent base periods.

Estimation of Smolt Production

Smolt production from several Puget Sound management units is estimated to provide additional information on the productivity of populations, and to quantify the annual variation in freshwater (i.e. egg-to-smolt) survival. Methods and locations of smolt trapping studies are described in detail elsewhere, but in general, traps are operated through the outmigration period of chinook (January – August). By sampling a known proportion of the channel cross-section, with experimental determination of trapping efficiency, estimates of the total production of smolts are obtained. These estimates are essential to understanding and predicting the annual recruitment, particularly in large river systems where freshwater survival has been shown to vary greatly. Abundance forecasts will incorporate any indications of abnormal freshwater survival.

It is known that survival of ocean-type chinook juveniles is highly dependent on favorable conditions in the estuarine and near-shore marine zones. For many Puget Sound basins, degraded estuarine and near-shore marine habitat is believed to limit chinook production. Studies are underway to describe estuarine and early marine life history, and to quantify survival through the critical transition period as smolts adapt to the marine environment.

Table. D-2 Schedule for annual development of harvest management objectives

Date	Event
September	Identify changes to forecast methodologies and fishery assessment model within the PFMC process
November	Exchange and finalize preseason planning data
January	Exchange preseason forecasts Prepare draft post season report
February	Finalize preseason forecasts Finalize post season report Finalize fishery assessment model inputs
March	Develop management objectives, baseline fishery proposal, initial ocean fishery options Exchange preseason management objectives and stock status information with Pacific Salmon Commission and Canadian Department of Fisheries and Oceans Adopt initial set of ocean fishery options for public review within the PFMC process Refine regional fishery options, define additional fishery assessment model runs as necessary Prepare draft of the annual Co-managers Fishery Management Plan
April	Adopt ocean fishery option within the PFMC process Finalize regional fishery option Finalize annual Co-managers Fishery Management Plan

17 Appendix E – Format for the Post-Season Report

1) Overview – Descriptive narrative of past season, which highlights significant deviations from pre-season plan or expectations.

2) Season Summary
   - Management Objectives – Listing for all management units
   - Regulations to Achieve Objectives –
     1. Description of the fishery regulation package and the preseason model run showing how the objectives were expected to be achieved.
     2. Description or narrative summary of the actual fishing season, especially deviations from the preseason plan taken in response to in-season catch and/or abundance information.
   - Southern U.S. Harvest Levels – Catch totals listed by category: troll, net, recreational

3) Test and Update Fishery Summary – Results from test and update fisheries for management units that are managed by in-season run size updates.

4) Performance Analysis
   - Escapement Estimates – Listing for all management units
   - Pre/post Season Run Size Forecast Comparison (includes in-season updates where applicable)
   - Exploitation Rate Assessment (as data becomes available)